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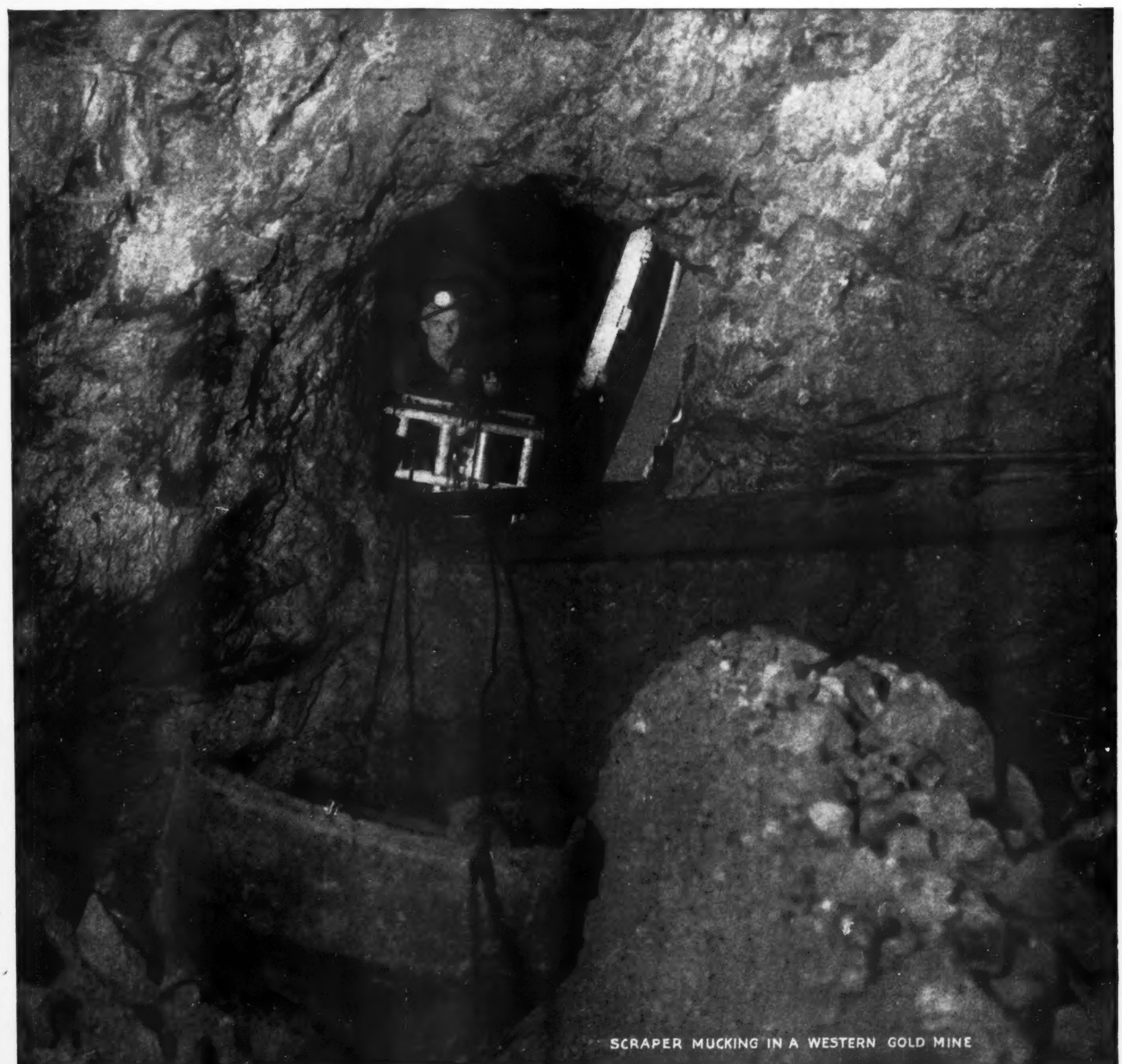

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OUR COVER PICTURE

MUCH of the movement and loading of ore in underground mines is now accomplished with scrapers drawn by wire ropes and powered by compressed air hoists. Our cover picture was taken in a stope of a western gold mine. It shows an Ingersoll-Rand 2-drum Utility hoist pulling a scraper of ¾-ton capacity to a loading chute.

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IN THIS ISSUE

A MORE equitable distribution of moisture is one of the prime needs of the semi-arid West where, roughly, one-third of the nation's area must depend upon irrigation for the raising of practically all crops. Nature concentrates its precipitation in the higher mountains, where snow banks remain throughout the year. Man's task is to conserve, direct, and divert the resultant water flow so that as much land as possible may be served by it. The U. S. Bureau of Reclamation has for many years been a leading factor in this movement. The Central Valley Project of California, which is described in this issue, is one of the bureau's most ambitious undertakings, but one that promises to repay its cost in a relatively short time.

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NOT so long ago gas was gas and oil was oil, but that was before the discovery of the phenomenon of retrograde condensation. It is now known that gas and oil occur at deep levels and under high pressures in a single phase in which the components are indistinguishable from one another. Reduce the pressure and the components separate. But if the pressure reduction takes place underground, the oil will be lost forever. To obviate such loss, the oil industry has devised a new production technique. It is called recycling and is explained in our second article.

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DEER ISLE, just off the coast of Maine, has a year-round population of only 3,000 persons, but each summer it is visited by thousands of tourists. In the future even greater numbers will pause there for a day, a week, or a month, thanks to a new suspension bridge that links the island with the mainland. The bridge, which is described in this issue, fills a long-felt want, for small ferryboats have provided the only transportation service available in the past.

Compressed Air Magazine

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EDITORIAL CONTENTS

ADVERTISING INDEX

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Central Valle Pro

SCALING CANYON WALLS

The first attack on the steep slopes was made with Jackhamers, the drillers clinging to the cliff like flies or, in the more perilous places, being suspended from ropes. During these operations, Jackbits were used for drilling to save the cost and effort of getting conventional drill steels to the inaccessible working points. As soon as possible, benches were established so that wagon drills could be employed, as shown in some of the illustrations on following pages.

le Project of California

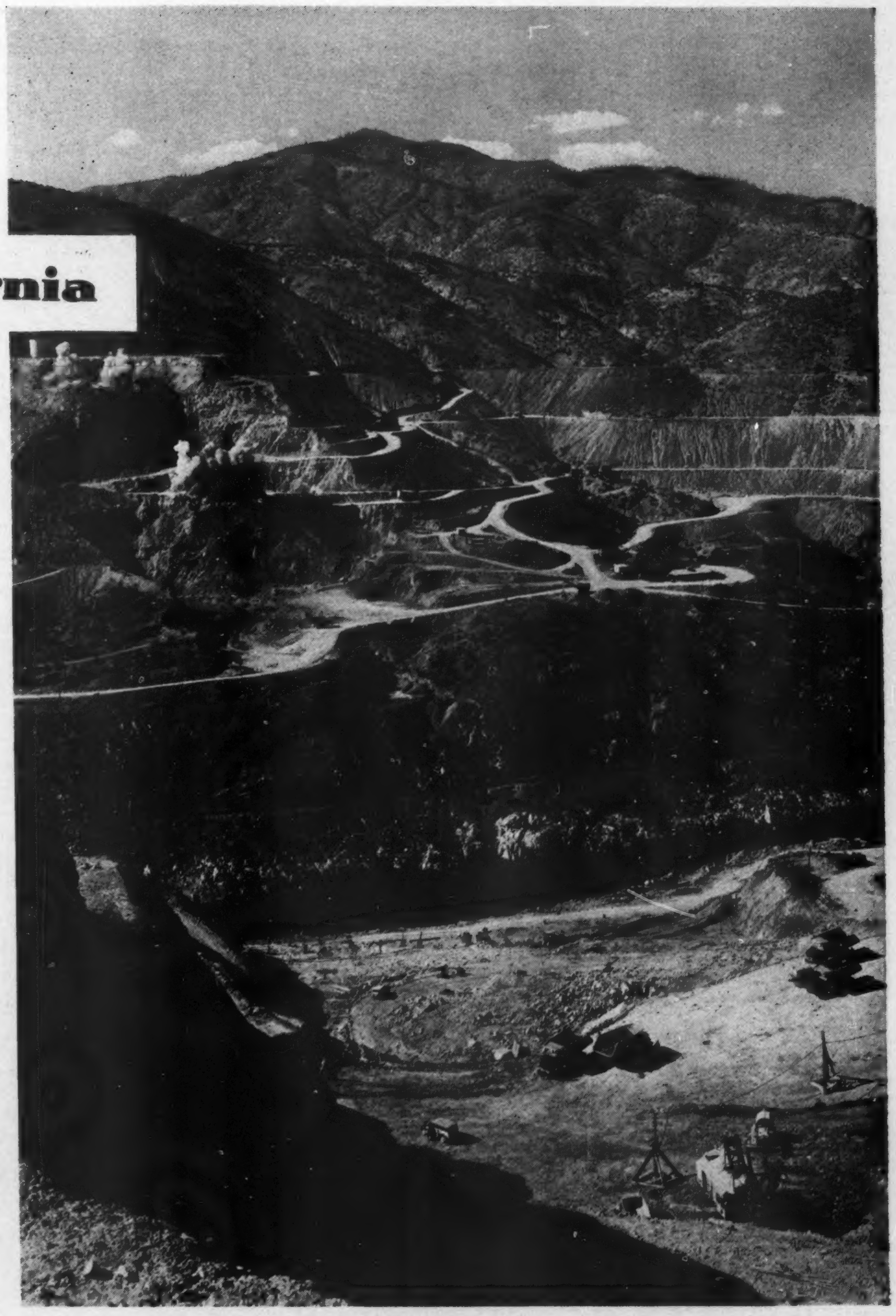
Henry W. Young

IT HAS been said that the Central Valley Project of California is one of the greatest reclamation enterprises in history. Concerning its greatness there is no question. But it also bears another distinction. It is not being carried out to develop some new and untried area, but to preserve and to improve something that already exists. That something is the very heart of the second largest state in the Union—an inland, agricultural empire that is already producing and that is supporting at the present time nearly 1,000,000 people.

Why say preserve? What threatens it? The answer is: Too much water. Too little water, and salt. Nature's timing is bad. Both seasonally and geographically the water resources are out of balance with the requirements of the irrigable lands. And so the U. S. Bureau of Reclamation, which may be classed as one of the world's largest construction agencies with 147 dams to its credit, has stepped in to restore the balance and to prevent great sections of the fruitful valley from reverting to the desert from which it came and toward which it is now headed. It is a big job, estimated to cost, in the end, about $170,000,000.

The best way to get a general idea of the whole thing is to spend a few minutes with the accompanying map. The Central Valley is a combination of two valleys—that of the Sacramento River from the north and of the San Joaquin from the south. The streams meet near Stockton, and empty into an arm of San Francisco Bay through a network of channels in a vastly productive delta. The aggregate length of the valleys is nearly 500 miles, and their width ranges from 50 to 100 miles. The gross area of the basin is 58,150 square miles, and the irrigable region affected covers 2,000,000 acres.

This is what is now happening. The water table of all the lower and central part of the valley is dropping year by year. As irrigating is done principally by pumping, wells have gone deeper until they have reached a point where it would be economically prohibitive to go still deeper, especially in the southern end of the San Joaquin Valley. Already, 50,000 acres once given over to production have been abandoned, with 200,000 more threatened in the immediate future. Even that isn't the whole story.



RIGHT ABUTMENT AREA, SHASTA DAM SITE

The gravity-type concrete dam to be erected here will be second in size only to Grand Coulee. It will be 560 feet high, 3,500 feet long at the crest, 580 feet thick at the base, and contain 5,600,000 cubic yards of concrete. Approximately 3,215,000 cubic yards of earth and rock are being excavated from the site. This picture was made while blasting was in progress. A section of the left abutment area is shown in the foreground.

From the north, almost every year, the Sacramento comes down with disastrous floods at a time when the land does not need the water. Aside from the damage done by them, particularly in the vicinity of Sacramento, the water is wasted. Then, when the river subsides, it goes rather abruptly to a low stage throughout the dry season. All the while the salt waters of the ocean have been lurking in San Francisco Bay. When the Sacramento gets so low that it can no longer hold them back, they begin to push their way into the channels of the delta, destroying the usefulness of thousands of acres of these highly productive lands.

In briefest outline, what the Bureau of

MAP OF CENTRAL VALLEY PROJECT

Broadly speaking, the aim is to bring about a better distribution of the waters of the Sacramento and San Joaquin rivers to the lands of Central Valley and to prevent the infiltration of salt water in the area adjacent to the coast. The Shasta and Friant dams will impound flood waters, which will be released during seasons of low flow and distributed more equitably over the valley through a series of canals. Power generated at Shasta Dam will be used for the necessary pumping. The ultimate cost of all this is estimated at $170,000,000. The irrigable land in the valley totals 2,000,000 acres; but a considerable extent of it has lost all or part of its productiveness because pumping from wells has lowered the water table and created semidesert conditions. Work on the Friant Dam is expected to start within a short time.

Reclamation is doing is to rear two dams—the Shasta and the Friant. The latter, soon to be started, is to be built across the headwaters of the San Joaquin River in the Sierra Nevada Mountains. Impounding its waters, it will serve to control the flow of that stream throughout the year. From the reservoir, a long canal will extend south to the Kern River near Bakersfield. This will be a "young river," 68 feet wide at the surface, 30 feet wide at the bottom, and 15 feet deep in the upper reaches. It will be 160 miles long and have an initial capacity of 3,500 second-feet. A shorter and smaller canal will divert 1,000 second-feet 40 miles to the Chowchilla River north of Madera. These two canals will take care of the irrigation requirements of the southern part of the Central Valley.

Far to the north, near Redding, the great Shasta Dam is being constructed athwart the Sacramento. It is the second largest concrete structure in the world, being exceeded in volume only by the dam at Grand Coulee. In its reservoir—some 35 miles long and extending, as well, up two tributary rivers, the Pit and the McCloud—will be stored 4,500,000 acre-feet of water from a tributary drainage area of 6,665 square miles. This reservoir will be made to stabilize the year-round flow of the Sacramento, and, incidentally, will restore all-year navigation on that stream as far north as Red Bluff. By checking the seasonal waste of water, it will be possible to improve irrigation in much of the Sacramento Valley, to repel salt-water intrusion into the delta, and to provide for the ultimate generation of 375,000 kw. of electrical energy. With these services performed, the Sacramento will have some water left over for "export."

From Shasta Dam, a 200-mile transmission line will be built south to a substation at Antioch. This power will be used in part to operate another feature of the project, the San Joaquin pumping system that will lift delta water up the San Joaquin Valley to a point where it will meet the Friant control. Through the network of 550 miles of channels and sloughs in the delta, a cross channel will be excavated to facilitate fresh-water flushing of the sometimes salty waterways. Four pumping plants will then lift 350 second-feet of water at sea level 124 feet into the Contra Costa Canal, the first part of the work to get underway. The water will flow by gravity throughout the 46-mile length of this canal, and will afford a dependable supply for industrial consumption along the shore of Suisun Bay, for domestic and municipal use, and for a large area of upland orchards and fields.

The outstanding feature of the whole project from the construction standpoint is Shasta Dam. It is being built on a slightly curved axis across a deep canyon, which runs approximately northeast and south-

west at that point. It is to be of the concrete gravity type, embodying an internal cooling system, an impervious curtain beneath, and all the other precautionary measures necessary in so large a structure. The maximum height will be 560 feet; crest length, 3,500 feet; top thickness, 37 feet; and base thickness, 580 feet. Excavation of all classes will amount to 3,215,000 cubic yards, and the concrete in the dam to 5,600,000 cubic yards.

Coupled with the construction of the dam is the relocation of a section of the Southern Pacific Railroad now passing through that part of the canyon that is to be flooded. A new high-line route was chosen several miles to the east and approximately 30 miles in length, as against 37 miles at present. The line includes twelve tunnels and eight major bridges. One of these, across the Pit, will be 3,590 feet long and rise 500 feet above the present river level. It will be, it is said, the world's highest double-deck bridge, carrying four highway traffic lanes and two railroad tracks on a deck below. Along the major stretch of the new rail route grading is now in progress, tunnels are being driven, and bridges are being erected by the various contractors.

Railroad relocation presented a problem in itself, as the existing right of way traverses an area included in one of the dam abutments. As it will be two or three years before the high line will be ready for service and the road moved, provision had to be made for the passage of trains over the old route while the work of excavating and construction was going on. This has taken the form of a double-purpose by-pass tunnel, 1,820 feet long, under the right or west area. This has been finished, and trains are now running through it. When the railroad has been shifted, this tunnel will be available for river-diversion purposes until the completion of the dam. Then it will be sealed with a plug of concrete 162 feet long.

As is the usual practice on its projects, the Bureau of Reclamation furnishes the materials that go into the dam structure. The actual construction work is being done by Pacific Constructors, Inc., a firm that is made up of twelve of the leading contracting concerns in the country and that provides its own equipment and supplies, camp buildings, etc. As low bidder, it was awarded the contract for the dam for $35,939,450. The by-pass tunnel was a separate contract, going to the Colonial Construction Company.

Excavation for the Shasta Dam, on which preliminary work was started early last fall, was approximately two-thirds completed by June 15, at which time the Colonial Construction Company had driven the by-pass tunnel and turned it over to the railroad. Spectacular features in connection with the digging and disposal of materials are lacking. The high degree of accessibility of the site and the "lay of the land" called for no giant conveyor belts such as at Grand Coulee. Also, only a comparatively small amount of muck had to be removed in the case of the diversion channel. The problem is simply one of excavating the steep hillsides down to solid rock, cutting through that formation, classifying the excavated materials as they come out, and using them for the purpose for which they are best adapted—for upstream embankments adjacent to the abutments, or as waste. The longest hauls have hardly been in excess of a mile, and it has been a straight trucking job from the start.

Two notable features, however, characterize the excavation work. Pacific Constructors, Inc., are making use of wagon drills on a scale bigger than ever before on any construction project. The second feature is the advent of the 25-cubic-yard, butane-powered motor truck, eighteen of which were specially built for this job. To

SOME OF THE WAGON DRILLS

More wagon drills are concentrated here than were ever before used at one location. Forty-two Ingersoll-Rand Type FM-2 units are in service. From 400 to 600 holes, each 20 feet deep, are drilled daily.

drill and to loosen the rock faster, and to get it away in larger carriers than have heretofore been employed on undertakings of this kind, are the two main elements in the plan that is successfully meeting the problem which the removal of the tremendous volume of material presents.

As will be seen in the general view of the dam site, the contractor proceeded to build a series of arterial roads approximately parallel to the river and at elevations 100 feet apart. The embankments were made largely from the wasted material of the overburden. From the arteries, short ramps, with a 5 per cent grade, lead to each working level on the abutments. There are similar roads up on the left side of the river, the one toward the observer, on which the contractor's offices, shops, hospital, dormitories, and other buildings are located. Directly in front is the excavation for the left abutment, and next to it, but not shown, is being placed a large embankment which rests partly against the main dam and partly against the core wall. This will consist of a bottom layer of earth and rock fill, a layer of compacted rock, and, outside of all, a dump fill of rock. It will require a large amount of material of all classes.

The usual high-scaling operations were necessary in order to get in, for the canyon walls are considerably steeper than the photograph indicates. In this work, 36 Jackhamers were employed for plugging bowlders and for the removal of the rock

ERECTING STEEL FOR BRIDGE

The building of Shasta Dam makes it necessary to relocate a section of the Southern Pacific Railroad tracks. This involves the construction of 30 miles of line at a higher level, including twelve tunnels and eight major bridges. The largest of the bridges will span the Sacramento River and, with its approach viaducts, will be 4,346 feet long. The picture shows steel in course of erection by the American Bridge Company.

beneath the overburden until working tables were well established. Jackbits were used for drilling partly because of the ease with which they could be packed in on the steep slopes, as compared with long and heavy drill steel.

As previously mentioned, this construction project is characterized by the almost exclusive use of wagon drills after getting through to solid rock. The rock is a meta-andesite that fractures well and is not very tough on steel, although some hard streaks are encountered. A total of 42 such drills is in operation on the two abutments, all of them Ingersoll-Rand Type FM-2's equipped with X-71 drifter drills. There are several reasons why they have been found particularly effective and economical. They make it possible to employ long and heavy drill steels with bits of 1½- to 2¾-inch gauge; and the working depth (20 feet at the top down to 4 feet when approaching foundation rock) is well within the limits of this type of machine which will take a 6-foot steel and drill holes up to 24 feet deep in the softer rock overburden. Holes are spaced 10 feet apart each way, and the larger ones permit heavier loading and a consequent saving in powder.

Mounted on pneumatic-tired wheels and weighing about 1,500 pounds, the drills can be moved and set up readily at any location, and only three men are required for the transfer, even in tough places. They will drill at any angle from vertical to horizontal because of the air-motor-controlled pressure feed. The range of feed pressure is from 0 to 1,000 pounds. By means of a ratchet and worm gear, one man can quickly raise and lower the drill guide in the uprights. There is also a self-locking worm feed operated by an air motor. This assures the right amount of pressure and eliminates jump-back of the drill in hard spots. Neither will it jump forward when soft spots are encountered or when a drill steel breaks.

HORIZONTAL AND VERTICAL DRILLING

One of the advantages of modern wagon drills is their flexibility. The drill can be tilted at any angle from vertical to horizontal, and with very little manual effort. Note also the pneumatic-tired mounting that facilitates movement of the unit over sloping, uneven ground.

Another factor in favor of the wagon drill is its effect on the operator. It is easier to work with than the hand-held drill; and he does not tire so readily. Experience on this job has shown that the type of man that makes a good wagon-drill operator does not differ materially from the one that makes a good Jackhamer operator. In either case, he generally has to be trained. The excavation foremen say that they can take a chuck tender and make a first-rate wagon-drill operator out of him in about a day or two. Mechanics generally seem to take well to the work and to find it agreeable.

The FM-2's have been able to average 200 feet per drill per shift of 6 hours and 40 minutes, contrasted with about 60 feet possible with hand-held drills of smaller size. Not all the units can be worked continuously because of operating conditions. But, at that, the contractor has been getting regularly from 200,000 to 300,000 lineal feet of hole each month. Last December, with 38 machines working, 300,000

lineal feet of hole was drilled. In May, last, 26 made an average of ½ foot of hole per minute, including moving time. Steel is sharpened at two conveniently located shops, one on each side of the river. Each is equipped with two I-R No. 54 drill sharpeners.

Air is furnished by a central compressor plant near the left abutment. This plant houses four 2,650-cfm. units, all discharging into one 12-inch header line. There are four receivers—two on each side of the Sacramento—feeding 8-inch pipe lines. Branches lead from these to the working sites, where the drills are supplied with air through 1½-inch hose connections. From 400 to 600 twenty-foot holes are drilled daily. These are loaded according to depth and shot twice a day. The 20-foot spring holes take from 50 to 60 pounds of explosive—40 per cent Quarry Special—per hole. Holes not sprung are loaded with 40 per cent gelatin. Electric caps are used in each case, frequently delayed, from one up to twelve delays. The charges are hooked to a bus line, using 240-volt power on the firing line.

Compressed-air applications are in evidence throughout a wide area in the vicinity of the dam. The railroad relocation work, extending northward for 30 miles, calls for air on every contract, whether for bridges, grading, or tunnels. There are fourteen different contracts on this new high line, a few of which are to be let while the others are in various stages of construction. Of these contracts, the first in line from the south is known as the First Crossing Bridge over the Sacramento. This structure, which is nearly completed, embodies a 3-span river crossing and a long, curved viaduct over adjacent low land. The total length is 4,346 feet, and steel to the amount of 5,800 tons has gone into it. It has meant the driving of 154,000 rivets, work calling for many riveters and impact wrenches. Air for this erection job by the American Bridge Company was furnished by an I-R 315-cfm. stationary compressor aided by a portable of the same capacity.

From the north end of the First Crossing Bridge extends a 12½-mile section of grading. This is directly followed by tunnels Nos. 1 and 2, which are typical of the other bores on the line. These are being driven by the West Construction Company. One is 2,765 feet long, the other 2,684 feet, and both are of standard railroad section, 17 and 18 feet wide, respectively. The north portal of one faces the south portal of the other across a short fill at the edge of a deep canyon, so all the excavated material is wasted over the side of the fill. On a little plateau between the portals are the compressor plant and the drill-sharpening and other shops.

The two tunnels will involve the removal of 111,000 cubic yards of what is almost solid rock. Each is being driven from one end; and the jumbo employed at each heading is provided with eight DA-35 drifter drills. The rock being consistently hard, from 20 to 30 inches of hole has been obtained per bit. The cut holes are 13 feet deep, and the remaining ones 11 feet. The aim is to pull down approximately 10 feet at each round, using about 4 pounds of 40 per cent special gelatin powder per cubic yard of rock. The excavated material is loaded by a Conway mucking machine into 4-cubic-yard steel cars drawn by electric locomotives. The cars are transferred at the heading by a "cherry picker." Air for the various operations is supplied by a cross-compound compressor of 2,800-cfm. capacity.

The foregoing account is typical in a general way of all the tunnel work. By the middle of June, tunnels Nos. 8 and 9 were just starting, and Nos. 11 and 12 had been holed through. Others were not yet under contract. In one 5-mile section, on which bids were closed July 14, are located five of the tunnels—Nos. 3 to 7—strung close together like beads on a string. All these will call for air, and plenty of it.

CUTTING BACK CLIFF

Eight wagon drills massed on top of the west abutment starting the work of cutting back 45 feet into sound rock.

SHARPENING STEEL

The vast quantities of drill steel required for the many wagon drills are reconditioned in two shops, one on each side of the river. Each is equipped with two I-R No. 54 sharpeners.

And thus the operations go on. Looking down on all of it is Mt. Shasta, that double-peaked, extinct volcano towering 14,161 feet above sea level and contributing its glacial waters to the mighty Central Valley Project. It was a familiar sight to the frantic forty-niners, who little thought that the day would come when water would be more precious than gold. The Russians who migrated to Northern California in the early part of the nineteenth century gave it the name of *Tchastal*—the white or pure mountain.

Pacific Constructors, Inc., is composed of the following firms: The Arundel Corporation, Baltimore, Md.; Foley Bros., Inc., New York City; L. T. Lawler & J. C. Maguire Company, Butte, Mont.; W. E. Callahan Company & Gunther-Shirley Company, Los Angeles, Calif.; Shofner, Gordon & Hinman, Denver, Colo.; A. Guthrie & Company, St. Paul, Minn.; Hunkin-Conkey Construction Company, Cleveland, Ohio; and Griffith Company, Metropolitan Construction Company, American Concrete & Steel Pipe Company, D. W. Thurston, and L. E. Dixon Company, all of Los Angeles. William A. Johnson of Los Angeles is president of Pacific Constructors, Inc., Frank T. Crowe is general superintendent, and B. W. Goodenough is chief engineer.

Recycling—A New Oil-Field Process

C. H. Vivian

FIELD SEPARATOR AND PLANT EXTRACTION EQUIPMENT

The right-hand picture shows twin extraction units at the Cayuga plant. The equipment on the left is the original installation, while that on the right was added early this year to increase the plant capacity to 27,500,000 cubic feet of gas daily. In the foreground are intake and discharge pipes through which the stripped gas is conveyed to and from the compressors. In addition to recycling at Cayuga, the same operators are withdrawing some gas from the Trinity formation at a depth of around 8,000 feet, lowering its pressure sufficiently to cause the distillate to condense out, and then injecting the gas into the Woodbine formation at a depth of around 4,000 feet. In this case, no boosting of the pressure is required. One of the separators in which the condensate is recovered is seen in the left-hand picture. The vessel is built for a working pressure of 3,000 pounds per square inch. The recoverable liquid content of the gas is a little less than 1 gallon per 1,000 cubic feet.

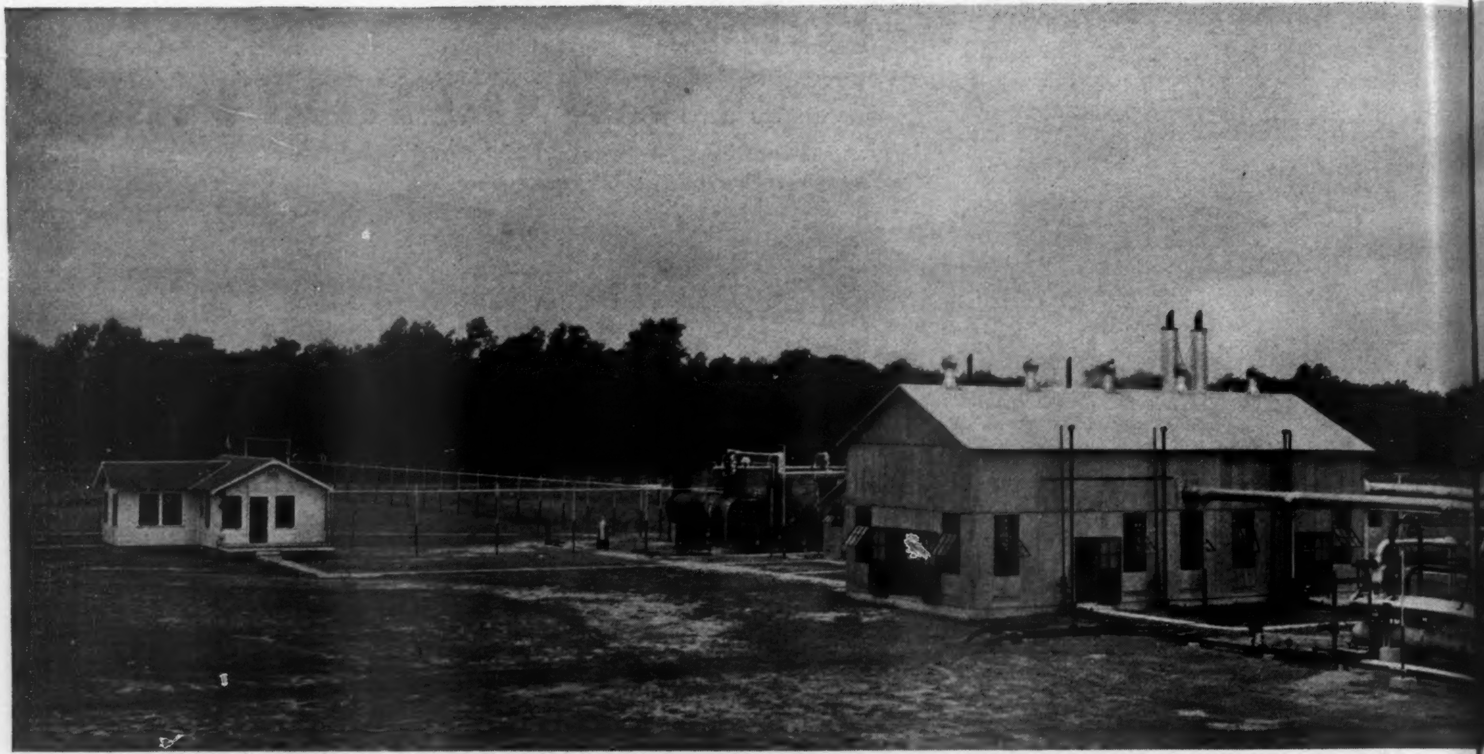
THE so-called distillate pools that have been discovered in recent years, principally in Texas, represent a new development in the petroleum industry. They have ushered in a distinctly new technology and obliged scientists to revise some of their conceptions of the physical laws governing the behavior of mixtures of natural hydrocarbon gases and liquids under pressure. It is only lately that much has been understood about them, and even now it is admitted that the knowledge of them is far from complete. It has been definitely concluded, however, that distillate fields will yield a substantial portion of our motor fuels in the future, and for that reason they are commanding the careful attention of the petroleum industry at present.

In order that we may have a clear conception of a distillate field, it will be well to point out wherein it differs from the ordinary oil or gas field encountered the globe over. In the ideal textbook type of geological structure, the underground strata are arranged in the form of a dome. The productive formation is a layer of porous rock, either sandstone or limestone, overlain by an impervious stratum. Oil occupies the flanks of the dome, with gas in the central section above them. If the drill penetrates the crown of the structure, a gas well will result. If it taps the reservoir rock farther down the slopes of the dipping formation, oil will gush forth, propelled by the pressure of the pent-up gas and of the overlying rocks. Considerable gas that has been in solution in the oil will be produced with it.

In some cases the gas cap is large in proportion to the volume of oil, and in others it is small. Sometimes no oil is present, and then we have a natural-gas field, such as those in the Texas Panhandle that now supply numerous cities in the North. In either case, however, there is a distinct difference between the two types of fluid. One is a liquid, and the other is a gas, and each one occurs as such in the underground storage reservoir from which it is derived.

But as wells go deeper, greater pressures are encountered, and it is sometimes found that the simple equilibrium relationships between liquid and gaseous hydrocarbons do not hold. That is, instead of existing as two distinct components, the liquid and gas occur in a single gaseous phase. However, if this gas is brought to the surface, and the pressure on it is released, liquid will condense out of it. A well of this type—one in which the hydrocarbons are in one phase in the reservoir rock—is called a distillate well.

This phenomenon of liquid condensing out of the gas when the pressure is lowered is contrary to accepted physical laws. One of the established processes of producing natural gasoline from a wet gas is by the compression method. When the pressure on the gas is increased to a suitable point, a large part of the higher-boiling hydrocarbons present are liquefied. Similarly, in commercial practice, oxygen, carbon dioxide, and other gases are liquefied by compressing them. In making natural gasoline by the compression method, the most effective pressure for maximum recovery depends upon the composition of the gas. In some instances in the past it was noticed that when operating pressures were increased beyond a certain point the yield of gasoline became less, but it was not generally understood why this was so. It is now known that some of the hydrocarbons that will liquefy below this optimum pressure tend to revaporize and to pass into the gaseous phase when that optimum point is exceeded. As the pressure is still further increased, more of the hydrocarbons have a tendency to do this. Ultimately, a pressure is reached where there is only one phase, the gaseous phase, and that is the



PANORAMA OF CAYUGA PLANT

Approximately 25,000,000 cubic feet of gas is put through this plant daily, yielding more than 20,000 gallons of condensate. The gas comes in at around 1,470 pounds pressure, is dropped to about 1,200 pounds during the processing, and is then boosted to 1,600-1,650 pounds to enable it to be returned to the formation that produced it. Essential to the process employed at Cayuga is equipment for dehydrating the gas and for reducing its temperature—a combination that makes it possible to obtain as high an extraction of condensate at 1,200 pounds pressure as would be obtained at 900 pounds if those features were not employed. Treatment at the higher pressure has the obvious advantage of reducing the horsepower required to raise the pressure sufficiently to inject the gas back into the ground. The structure at the extreme left is the office and laboratory. Next in line are the boilers and the compressor house. In the center is pictured the refrigerating and dehydrating equipment, as well as the extraction accumulator where the condensate is precipitated out of the gas by dropping the pressure. Farther to the right is the water cooling tower. The two tall cylinders in front of it are stabilizers for treating the condensate to obtain a more marketable product. At the extreme right are the tops of a row of tanks in which the stabilized condensate is stored. The plant serves five withdrawal and five input wells in a field of about 12,000 acres.

condition that prevails in the distillate fields.

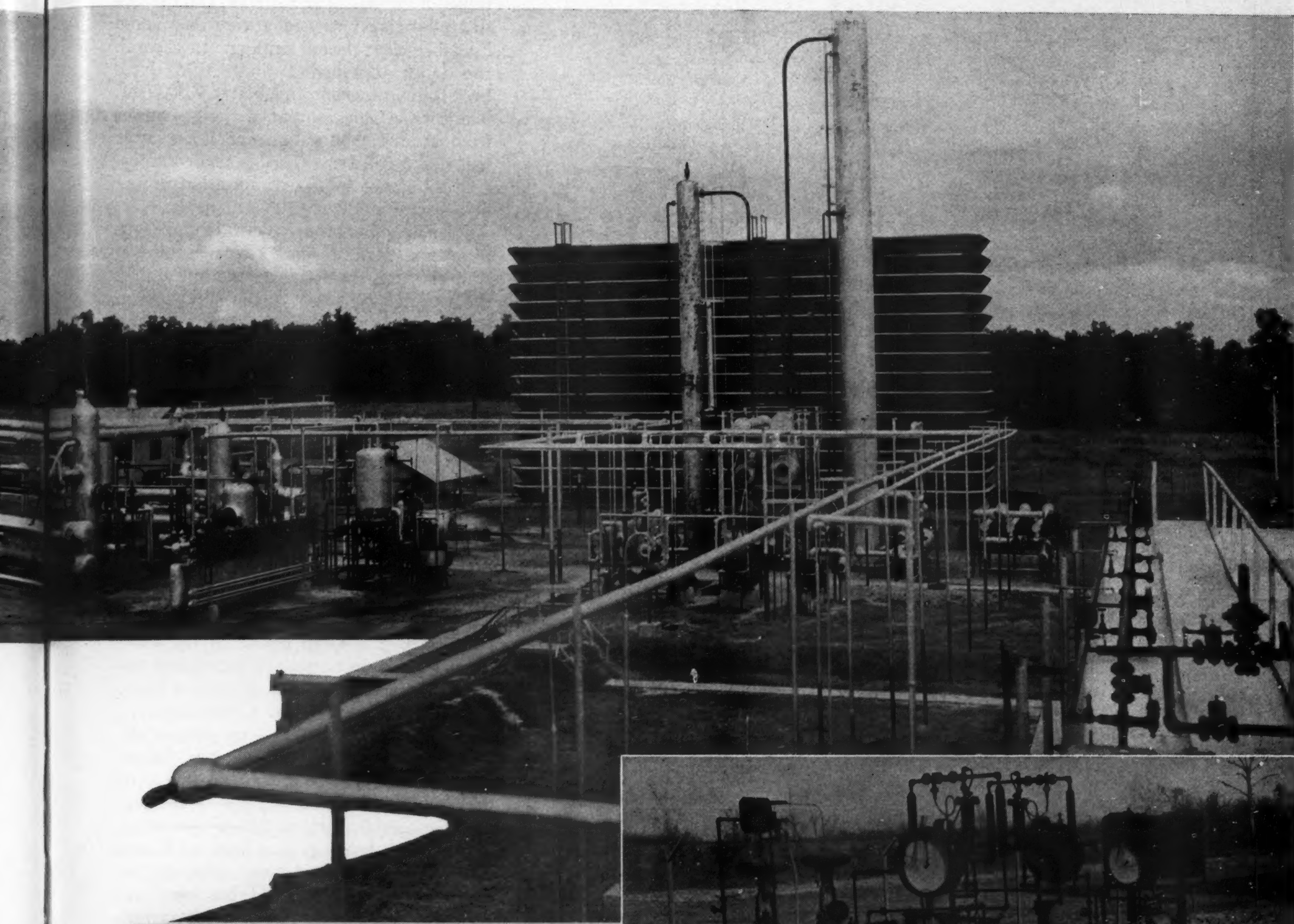
Conversely, if the pressure on such a gas is released until it is below the critical point, liquid will condense out. This phenomenon has been termed retrograde condensation. It was first revealed by Dr. William N. Lacey of the California Institute of Technology during the discussion of a paper on the Big Lake Field of Texas that was presented before a meeting of the American Petroleum Institute at Houston, Tex., in 1932. At that time, Doctor Lacey stated that "at higher pressures, liquids have higher vapor pressures than is ordinarily the case. At considerably higher pressures, such as 3,000 or 4,000 pounds, that effect is quite marked. Liquids that ordinarily have fairly low vapor pressures have high ones under those conditions. At about 185°F., and 3,000 to 4,000 pounds pressure, the upper zone of the Big Lake Field, with its water white oil, is existent in the gas phase entirely."

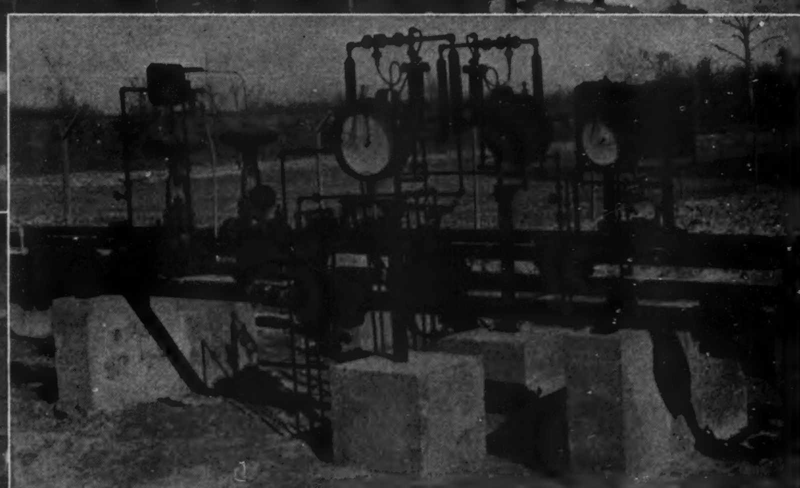
Doctor Lacey thus voiced a theory that was received with much skepticism by those present. In fact, it was given practically no publicity and little attention, except possibly in the realms of pure science. However, subsequent investigations and observations have proved the theory to be correct. It will be noticed that he referred to the liquid that was being condensed out of the gas of Big Lake Field as water-white oil. This color is characteristic of the material obtained from most of the distillate fields, and because of that they were formerly called water-white oil fields.

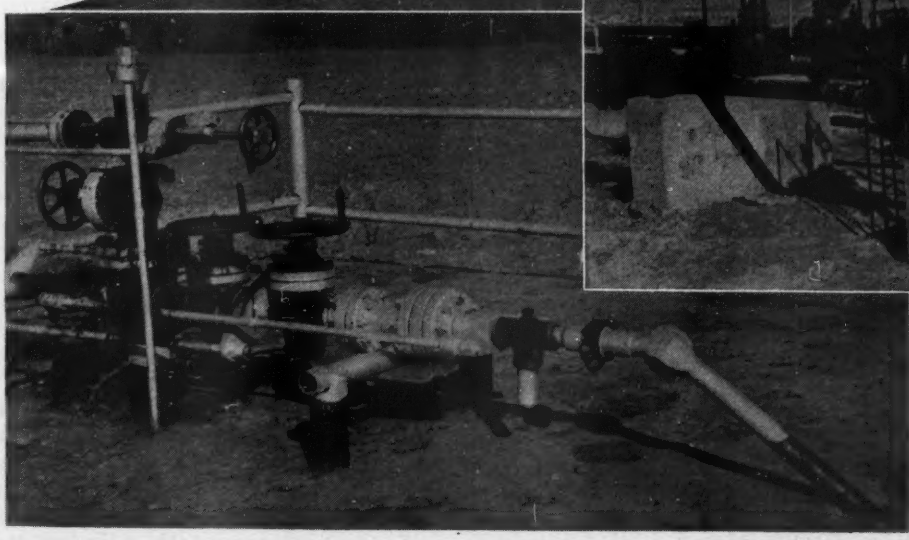
In composition, most of the oils conform fairly closely to the specifications of gasoline or of kerosene, and can be used as motor fuel by simple distillation, although the octane rating is usually low. However, in some cases the condensate is brownish, and there is reason to believe that under sufficiently high pressures perhaps the entire range of hydrocarbons that goes to make up crude oil can and does occur in the single gaseous phase. Accordingly, it is possible that, with deeper drilling, gas may be produced from which there can be condensed out a liquid of the nature of petroleum that can be distilled to yield lubricating oil, kerosene, and the various other derivatives that are now commonly manufactured in refineries from crude oil produced from shallower depths. However, it may require pressures of the order of 25,000 pounds per square inch to do this.

In some fields all the hydrocarbons present are in the single gaseous phase. In other cases, only those in the upper portion of the structure are in this category, with crude oil in the lower parts and underlying the gas, this being analogous to the relationship between oil and gas in the case of a simple dome. In the typical distillate field, however, there is no oil. It is now known that some fields which in all probability contained an upper horizon of distillate were discovered before the mode of occurrence that has been described was understood and their true character could be recognized. Among these are Kettleman Hills Field in California, the Oklahoma City Field, and Turner Valley Field in Canada.

Inasmuch as liquefaction of some of the hydrocarbons is brought about by dropping the pressure of the gas below the optimum pressure, it will be apparent that this is all that is necessary to produce the condensate. As a matter of fact, a considerable yield was obtained in this manner until recently. The raw gas issuing from the well head was run into a separator, the pressure was reduced to "knock out" the condensate, and the residue gas was in many instances burned at flares. Obviously, this was a very wasteful and crude method of separation, not only because the dry gas







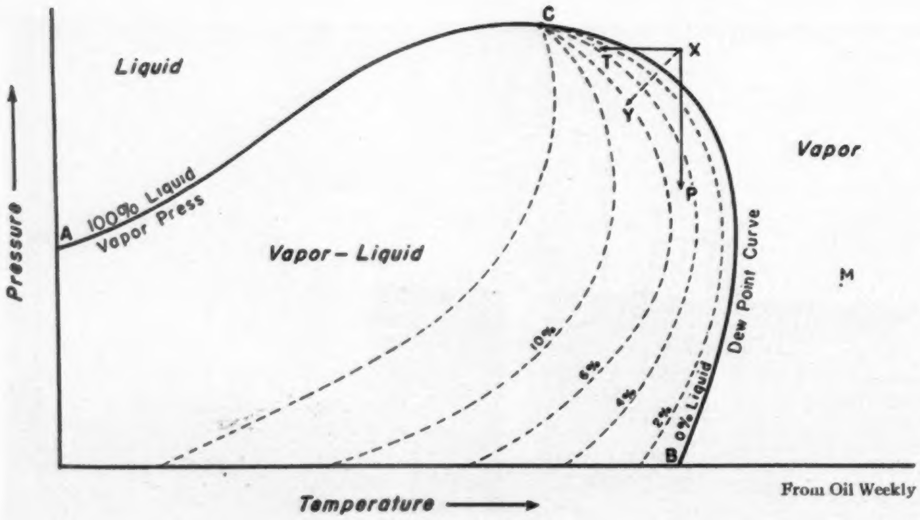
METERS, INPUT WELL

Meters on both the incoming and outgoing gas lines are shown above. Pictured at the left is one of the five input wells through which the stripped gas is returned to the producing formation. A high-pressure check valve is placed in the line just ahead of the well-head connection.

was dissipated but also because some of the more volatile and valuable liquefiable constituents of the raw gas were not recovered. But there was no ironclad legislation to prevent it.

The wasting of gas from gas wells was prohibited in Texas in 1935 by an order of the Oil & Gas Division of the Railroad Commission of the state. However, operators who were producing condensate in this manner contended that the wells were oil wells and that, under the existing laws, they were permitted to waste gas that was produced with oil. Meanwhile, the question was threshed out in the courts, and the Commission's contention that most distillate wells are gas wells and not oil wells was upheld in the case of Clymore vs. Thompson. A further order was issued on January 18 of this year definitely classifying as a gas well any well that yields less than one barrel of oil for each 100,000 cubic feet of gas. As there were already laws on the books prohibiting the production of gas unless it was to be used for certain specified beneficial purposes, this new order was of sweeping effect.

There was more back of this regulation, however, than the desire to conserve the dry gas that was being wasted. Continued production of the gas and failure to return



From Oil Weekly

PHASE RELATIONS OF SUBSURFACE HYDROCARBONS

A general drawing that explains the phenomenon of retrograde condensation. The line AC represents the boundary between the single-phase or liquid zone and the 2-phase or vapor-and-liquid zone. It is therefore the vapor pressure or bubble-point line. The line CB is the boundary between the same vapor-liquid region on the inside and the single-phase region on the outside. It is called the dew-point curve. At C is the critical point where the properties of the vapor and the liquid become identical and cannot be distinguished from one another. The dotted lines represent the percentage of liquid in the vapor-liquid region. Gas wells such as those of the Texas Panhandle have reservoir conditions falling to the lower right of the curve CB, indicated by the point M. It can be seen that throughout any pressure range at the given temperature the fluid will always remain a gas. Any appreciable temperature reduction will, however, cause condensation of the liquid, because the conditions would then fall to the left of the dew-point curve CB. The reservoir conditions of wells of the gas-distillate type are indicated by the point X. If the pressure is allowed to drop, it will fall within the 2-phase region at point P, and condensation of the liquid will result. A reduction of the temperature to the point T will have the same effect. A combination of pressure and temperature reduction will bring about the condition shown at the point Y. The condensation caused by lowering the pressure is called retrograde condensation, while that caused by lowering the temperature is normal condensation.

it to the formation would, manifestly, reduce the formation pressure below the critical point and cause the liquefiable hydrocarbons in all the gas remaining underground to condense there. This would not be seriously objectionable if the liquids formed could be subsequently recovered; but investigations had proved that they could not. The reason for this is that the ratio of liquefiable components to the entire volume of gas is in most cases very small. In the average distillate field, a drop in pressure would form only enough liquid to wet the sand grains and not enough to collect as a definite pool. Accordingly, all the liquid formed underground would be permanently lost.

Even prior to the issuance of the Railroad Commission's latest order, various responsible oil producers in Texas and Louisiana (in which two states are located most of the distillate fields thus far discovered) had realized that, if they were to obtain the maximum possible recovery from such fields, they would have to maintain the formation pressure at a level above the retrograde condensation point. The obvious way of doing this is to reinject the dry gas into the formation after the wanted liquefiable content has been condensed out of it. This method of operating the wells is termed recycling. This is perhaps a misnomer, as it is not the intention to recycle the same gas but, rather, to put it back into the ground at a point considerably removed from the withdrawal well and to use it to push untreated gas toward the latter.

A typical recycling operation consists of one or more withdrawal or key wells from which the gas is obtained, of a suitable plant for bringing about the condensation of the liquefiable hydrocarbons that it is desired to recover, of a compressor plant to boost the pressure of the gas sufficiently to return it to the underground reservoir, and of one or more injection or input wells through which the return to the formation is made. The processes employed by different operators vary in detail, but all of them involve reduction of the pressure to within the range of retrograde condensation. The entire technology of the extraction cycle is still far from standardized, and many problems remain to be solved, although much experimental work has been done and is being continued.

Upwards of 60 distillate fields have thus far been discovered in Texas alone, and more are being found as drilling is carried to continually increasing depths. Probably the first such field was brought in at Pine Island, La., in 1924, but it was not then recognized as such. The richest of this type now known is the Cotton Valley Field, in Louisiana, which yielded 1,469,803 barrels of condensate in 1938. In numerous cases, of which Cotton Valley is an example, conventional oil and gas production was obtained from shallower horizons, and the distillate-bearing formations were discovered by subsequent deeper drilling. In general, the depth at which distillate fields have been found ranges from 4,000 to 9,000 feet. The condensable content of the gas varies from around 0.50 gallon per 1,000 cubic feet to 4.5 gallons. There is also considerable difference in the composition of the liquid products from different fields.

Recycling has brought with it numerous problems with respect to maintaining equitable returns from production among the various owners of a field. Visualize, for instance, a situation where one company owns only ten acres, consisting of two 5-acre tracts a quarter of a mile apart. The company puts down a well on each tract, withdraws gas from one of them, processes it, and then returns it to the ground through the second well. Such a company not only may take gas from beneath a considerable area of land surrounding the withdrawal well, but by returning the stripped gas to the ground may also dilute the gas belonging to others, or even drive it out beyond the borders of their holdings.

There is likewise the problem confronting the owner of a small tract. If the withdrawal and injection wells are spaced too closely together, dilution of the gas being extracted will soon result. Consequently, a man holding only a few acres cannot obtain a sufficient return to warrant the expenditure required to put down two wells and to build an extraction plant. Because of these complicating circumstances, unitization of all holdings in a field, with proration of the expenses and earnings according to the acreage held, has been suggested as one way of obtaining maximum production for the field as a whole and equitable distribution of the profits. Because the liquefiable content in the formation is only a fraction as much per acre-foot as that in the average petroleum field, the spacing of wells in a distillate field must be considerably wider if the operation is to be economically justified. The spacing warranted will depend upon the recoverable condensate per 1,000 cubic feet of gas, upon the thickness of the productive formation, and upon other factors. One well will ordinarily withdraw gas from 250 to 640 acres at a sufficiently rapid rate.

The return from a recycling operation conducted under favorable conditions is very attractive. Assuming that the gas treated by a number of plants ranges in recoverable condensate content from 0.75 gallon to 2 gallons per 1,000 cubic feet, and that 25,000,000 cubic feet is handled by each plant daily, then there will be obtained from 18,750 to 50,000 gallons of condensate a day. This can be sold at from 2½ to 3 cents a gallon, yielding a gross return of from $468 to $1,500 a day. The cost of building such a plant, including the drilling of the wells, will be somewhere between $300,000 and $500,000. In addition to the immediate earnings, the dry gas returned to the ground for storage has a po-

tential future value which can be realized if a market for it develops. As an indication of the importance of distillate fields as a whole, it may be cited that those discovered to date and available for development could, it is estimated, produce 1,000,000 gallons of gasoline a day.

About ten recycling plants have been built so far, some of them being very small. The first one was put in service in January, 1938, by the Process Oil Company in the Agua Dulce Field of southern Texas. The second one was erected by the Tidewater Associated Oil Company and the Seaboard Oil Company of Delaware at Cayuga in east Texas. It began operating in March, 1938, as an experimental unit for the purpose of obtaining data to be used in the designing of additional plants. Early in the present year it was enlarged, and is now handling approximately 25,000,000 cubic feet of gas daily. This plant utilizes a process developed and patented by William H. Vaughan of Palestine, Tex. The Vaughan Gas Process Company, Inc., which is wholly owned by the Tidewater-Seaboard interests, has been organized to handle the licensing of the process to other operators. Details of the process were worked out in a pilot plant that was run for some time prior to the erection of the commercial plant.

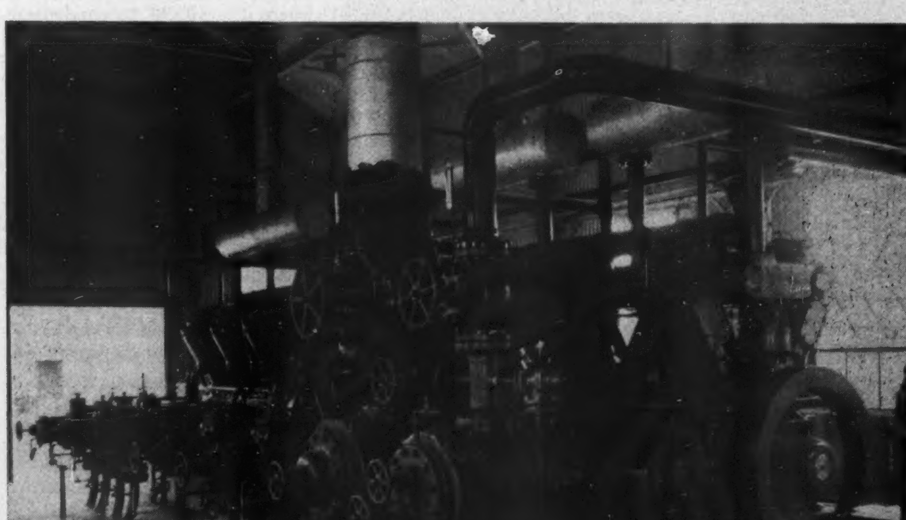
It will be apparent that the more the pressure is dropped to induce condensation of the liquefiable components of the gas, the greater will be the mechanical work expended to compress it to a pressure that will permit returning it to the ground. It is therefore desirable to limit the reduction in pressure so far as that can be done and still recover the maximum amount of desirable condensate. At Cayuga, this is accomplished by employing mechanical refrigeration. Some authorities have claimed that the retrograde-condensation pressure point remains unchanged regardless of temperature: but Mr. Vaughan cites the results of the plant's operations to support his contention that this is not the case. He states that of the gas thus far treated, none has been found from which it was not possible to recover a product of desired composition at a higher pressure with refrigeration than without it.

The Cayuga Field consists of about 12,000 acres. The distillate comes from the Woodbine sand at a depth of 4,050 feet. Although the field is four years old, it has been produced in such a conservative manner that the bottom-hole pressure has dropped only from 1,750 pounds per square inch to a little less than 1,700 pounds. Five withdrawal wells and five input wells are being used. The recoverable liquid content of the gas is a little less than 1 gallon per 1,000 cubic feet, or approximately 24 barrels per 1,000,000 cubic feet. The gas issues from the wells under a flowing pressure of 1,470 pounds and at a temperature of 125°F. It reaches the plant at substantially the same pressure, is dropped to 1,200 pounds during the processing, and is then compressed to 1600-1650 pounds to permit returning it to the formation.

A flow sheet of the plant is published among the accompanying illustrations. After being metered, the raw gas is passed through a tubular-type water-to-gas cooler and then to a separator, where free water, constituting about 80 per cent of all contained moisture, is removed. The gas is next further cooled by passing it through a heat exchanger in which dry gas that has been processed is used as the cooling medium. It is further cooled in an ammonia-to-gas heat exchanger. If any moisture remains in the gas, hydrates will form at around 70°F. when the pressure is reduced to 1,200 pounds and freezing will result. Accordingly, it is necessary that all water vapor be removed before the gas is cooled to the hydrate-forming temperature, and this is done by pumping a calcium-chloride solution into the stream before it enters the ammonia cooler. The cooled gas passes through a pressure-reduction valve and then into an extraction accumulator, where the pressure is reduced to 1,200 pounds. The temperature at that point is maintained at from -5° to +10°.

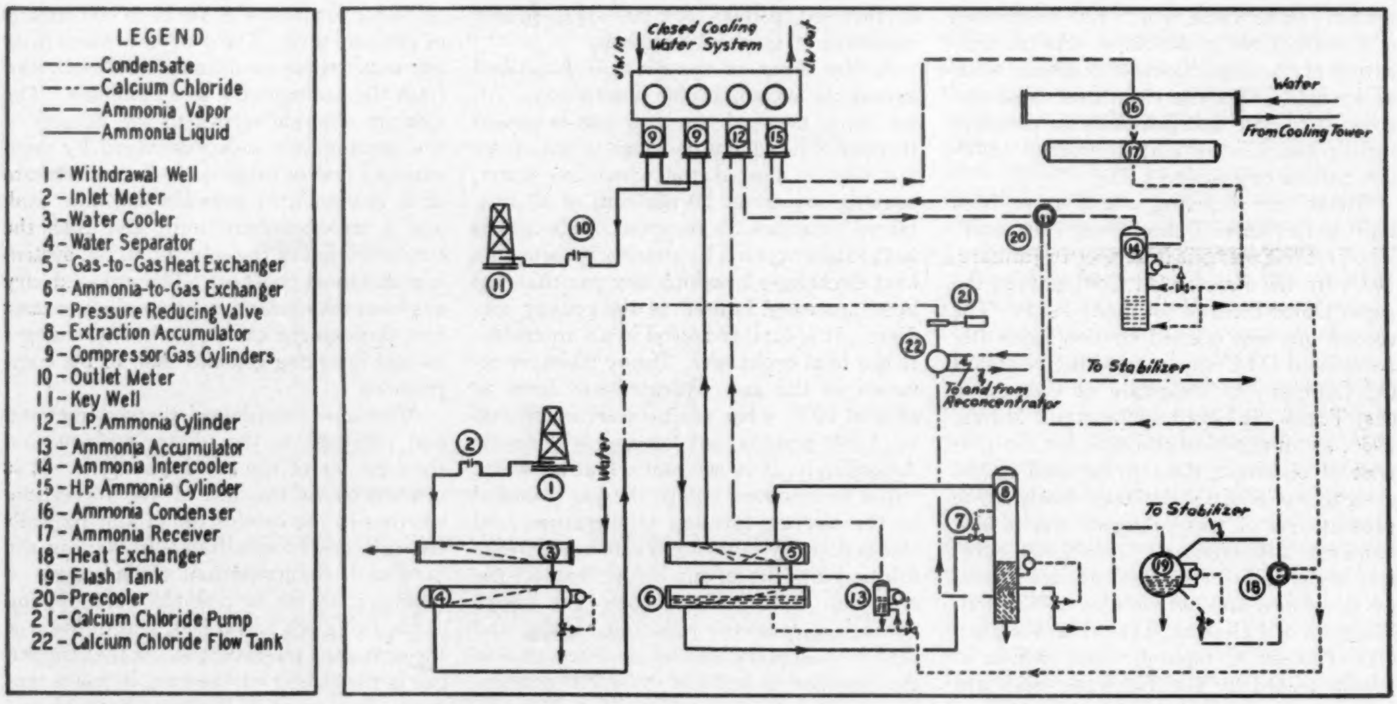
In addition to the cooling obtained by artificial means, the reduction in pressure has a natural refrigerative effect. This amounts to about 4°F. for each 100 pounds of pressure drop. The condensate separates out under these conditions and is delivered from the accumulator to a stabilizer. The calcium chloride settles to the bottom of the accumulator and is delivered by pressure to a flow or surge tank. A small stream of it is circulated between the flow tank and a reconcentrator unit, and thus the concentration of the solution in the system is maintained constant. The stripped, dry gas from the extraction accumulator passes first through the gas-to-gas heat exchanger to cool incoming gas and then to the compressors.

After being compressed, the gas is metered and returned to the producing formation through one of the five input wells. It is introduced at the top of the formation, whereas in the case of the producing wells the raw gas is withdrawn from near the bottom of the formation. This is done to minimize, so far as possible, commingling of the two gases and consequent dilution of the untreated reservoir gas. As the stripped gas is the lighter of the two, it has a tendency to remain in the top of the formation. Care has to be taken not to inject the treated gas at too fast a rate, as this would result in opening channels in the reservoir rock, with possible by-passing of the re-



COMPRESSOR PLANT

After the gas has been stripped of its liquefiable content, a small proportion of it is used as fuel for operating three gas-engine-driven compressors that perform the dual service of boosting dry natural gas to the required injection pressure and of compressing the ammonia gas used in the refrigeration cycle. The two complete machines at the left are Ingersoll-Rand Type XVG units. The first one is a 300-hp. combination gas booster and ammonia machine, with two compression cylinders for each of these services. It will handle 5,500,000 cubic feet of natural gas daily at an intake pressure of 1,200 pounds and a discharge pressure of 1,650 pounds. There are two single-stage gas cylinders, each 3¼x12 inches. The other two cylinders constitute a 2-stage 14&12½x12 ammonia compressor rated at 100 tons of refrigeration when handling ammonia gas at -15°F. intake. The far unit is of 225 hp. and is a gas booster only. It has a daily capacity of 9,500,000 cubic feet under the same conditions as those given for the first machine. Partly visible at the right is a 400-hp. compressor that produces 75 tons of refrigeration daily and also handles 12,500,000 cubic feet of natural gas.



FLOW SHEET OF CAYUGA PLANT

The course the natural gas follows is explained in the text. The ammonia is compressed in two stages. The low-pressure cylinder (12) takes the gas at -15°F. from the accumulator (13) and also from the chiller (6). From the low-pressure cylinder the gas passes through the intercooler (14) where it is cooled by liquid ammonia, and then goes to the high-pressure cylinder (15). After being compressed to the final pressure, the gas is discharged to the condenser (16) where it is cooled by circulating water and liquefied. The liquor next goes to the receiver (17). From the receiver it passes through the intercooler (14) and then to the cooler (18) where it is cooled to 10°-20° by condensate. From there it goes to the accumulator (13) where it is flashed to its final temperature and used in the chiller (6) to cool incoming gas.

turned gas from an input well to a withdrawal well.

En route from the extraction accumulator to the stabilizer, the condensate passes to a flash tank, where the pressure is reduced to 350 pounds. The gas in solution is thus flashed off and is delivered to a stabilizer column. The flashing causes a drop in temperature of approximately 20°F., and the condensate passes through a heat exchanger where it cools liquid ammonia. It enters the exchanger at a temperature of -5° to -20° and leaves it at about 30°. It is then utilized to precool ammonia gas between stages of compression, after which it passes to a stabilizer. The ammonia cycle is given in connection with the flow sheet of the plant.

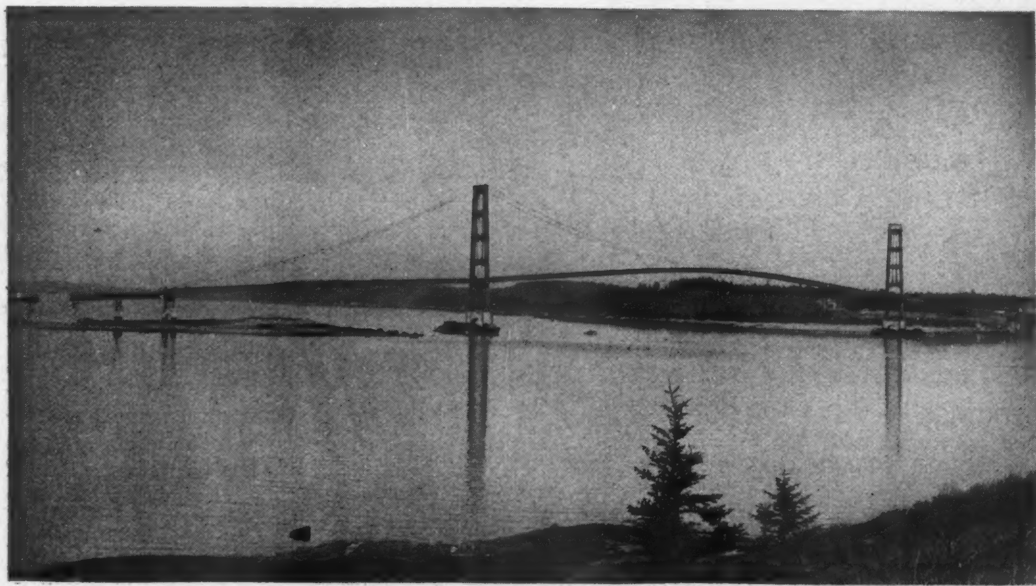
The effect of refrigeration in increasing the recovery of condensate has been demonstrated at Cayuga by operating the plant under varying temperature conditions while maintaining the pressure constant at 1,200 pounds. When operating at a temperature of 74° to 78°F., the average recovery of condensate from 1,000 cubic feet of gas was 0.46 gallon, or about 11 barrels per 1,000,000 cubic feet. With the temperature reduced to 60° and using dehydration, a yield of 0.54 gallon per 1,000 cubic feet of gas was obtained, or about 14 barrels per 1,000,000 cubic feet. With ammonia-chilling and reduction of the temperature to 8° or 10°, the yield per 1,000 cubic feet of gas was increased to 0.82 gallon per 1,000 cubic feet, or 20 barrels per 1,000,000 cubic feet. With a further reduction of temperature to zero Fahrenheit, a recovery of 0.92 gallon per 1,000 cubic feet was made, or 22.5 barrels per 1,000,000 cubic feet.

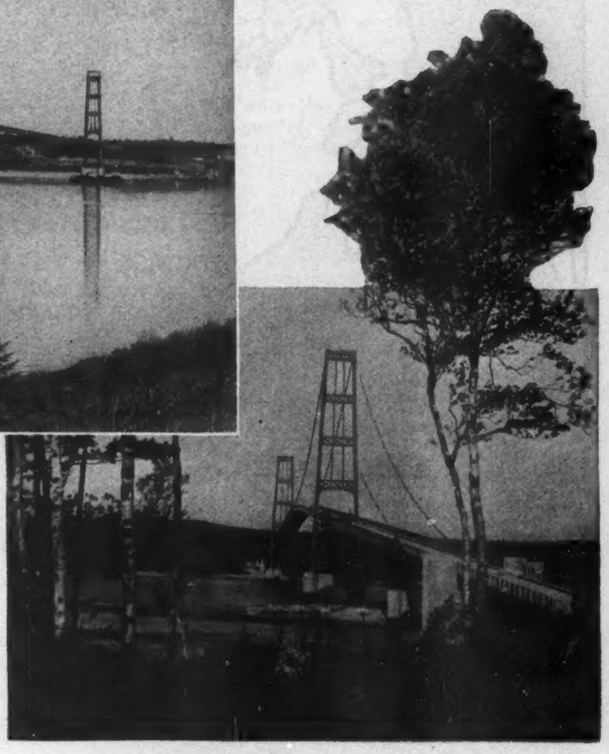
In view of these tests, Mr. Vaughan concludes that refrigeration at Cayuga results in an increase in condensate extraction of around 67 per cent above that which can be obtained by operating at 74°F. It also materially decreases the horsepower required to compress the dry gas to injection pressure, not only because of the reduced compression range but also because less gas remains to be handled. The additional condensation obtained, plus the contraction of the gas brought about by the drop in temperature, amounts to a total shrinkage in the volume of the dry gas of 6.7 per cent.

With the plant extracting condensate at 74°, the temperature of the dry gas at the compressor intake was found to be 83°, and when this gas was discharged for delivery to the input well its pressure was observed to be 1,750 pounds and its temperature 142°. With extraction at a pressure of 1,213 pounds and a temperature of 7°, the temperature of the gas at the compressor intake was 54°, and upon leaving the compressor it had a pressure of 1,662 pounds and a temperature of 121°. The lower discharge temperature of 121°, as compared with that of 142°, causes a greater volume of gas to be put through the compressor cylinders, lowers the friction in the discharge line to the input well, produces a cooler and therefore heavier column of gas in the input well, and reduces the viscosity of the gas when entering the underground formation. All these factors combined enable the compressors to operate at a lower discharge pressure.

All told, Mr. Vaughan states, the cooling of the gas to temperatures a little above zero brings about a decrease of around 20 per cent in the horsepower required for compression. Specifically, 20 hp. is needed per 1,000,000 cubic feet, as against 27 hp. when operating without refrigeration. This saving, he contends, is more than sufficient to offset the additional horsepower required to operate the refrigeration system. The cost of the refrigeration and dehydration equipment represents about 20 per cent of the entire cost of the plant. Since this part of the process is responsible for 40 per cent of the revenue, or a 67 per cent greater extraction than can be obtained when operating without it, it will readily be seen that the capital expended for the refrigeration equipment will be returned much faster than that invested in the plant as a whole.

A further advantage of operating at reduced temperatures is that it makes possible the recovery of a greater percentage of the lighter hydrocarbons, provided they are present in the gas to be treated. These lighter ends are desirable in the final product, as they bring it within the range of natural gasoline and increase the chances of marketing it. In most cases, they add to the octane rating, lower the end point, and otherwise improve the specifications.





Deer Isle--Sedgwick Suspension Bridge

R. G. Skennett

THE COMPLETED BRIDGE
At the top is a view from the east, with Sargentville on the right. The lower picture was taken from the shore of Little Deer Isle.

DEER ISLE is one of the largest and loveliest of the numerous rock-bound, timbered islands that dot the offshore waters of the coast of Maine. In the balmy summertime, the air there is redolent with the scent of the sun-warmed pine, the fragrance of the sweet fern, and the tang of the salt breezes sweeping in from the open sea. As a vacationland, Deer Isle has many things to offer the visitor seeking either rest or recreation.

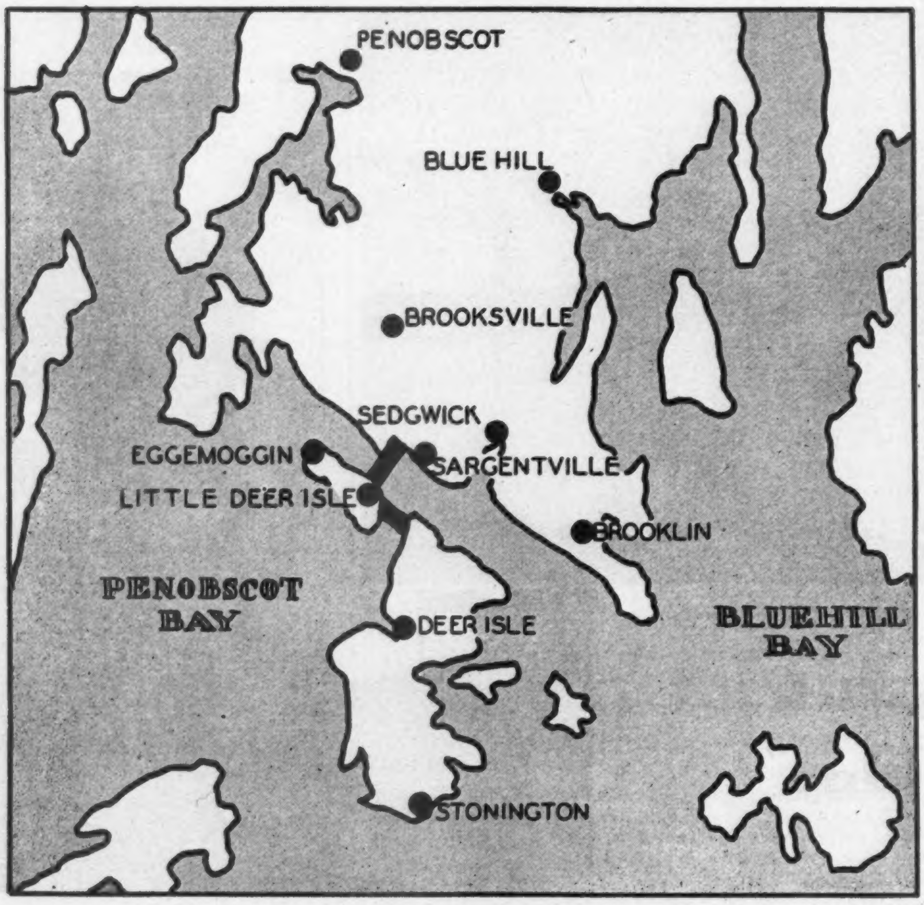
Even so, Deer Isle has yet to be seen by thousands of motorists and other tourists that make an annual trek to that section of our expansive Down East. This unfamiliarity has hitherto been due to the fact that Deer Isle is separated from the mainland by a waterway, Eggemoggin Reach, which for generations has imposed a degree of isolation upon the island. The water gap is about 10 miles long, and links the Atlantic Ocean with Penobscot Bay. During favorable weather it is much used by vessels of the fishing fleet, small coastwise steamers, and yachts. The channelway is deep, and the shores lie from ½ to 3 miles apart. Until lately, people and automobiles bound from Sargentville on the mainland to the Village of North Deer Isle on Deer Isle made the trip by ferry, a shallow-draft, open-deck scow towed by a small motor boat and carrying when crowded possibly four cars. The passage has varied in time, depending upon wind and tide; and foggy weather and rough water have invariably slowed progress and even caused a suspension of operations. This state of affairs has greatly checked travel between Deer Isle and the mainland; has retarded its development as a resort area; and has also had its reflexes upon the life and communal habits of the 3,000 persons who make it their home the year round.

Those of us that have some second-hand knowledge of Deer Isle are aware that its quarries have long been a source of large quantities of granite that is noted for its texture and its coloring; and we recall that time and again the men of its deep-sea fishing fleet have furnished the crews of such of our yachts as have raced in defense of the famous International Cup which we have held ever since the *America* won it in 1851. From now on the touring motorist and the people of the neighboring sections of Maine will be able to drive to and from Deer Isle across Eggemoggin Reach by the fine suspension bridge that was recently opened to traffic.

The Deer Isle-Sedgwick Bridge spans the reach between Sargentville and Little Deer Isle, which flanks the waterway on the south. At that point the latter is not quite half a mile wide. Little Deer Isle and the northwestern shore of Deer Isle are linked by a causeway that was built a while ago. The name of the bridge indicates the fact that the structure ties together two subdivisions of Hancock County—the townships of Sedgwick and Deer Isle, not the villages that bear those names. The people of those townships, through their joint efforts and the aid of the State of Maine and a PWA grant, are now placed in touch with one another as they have not been in the past, and are bound to be helped by the intercourse that the toll crossing will promote, while motorists from afar will find Deer Isle accessible day and night in all seasons that permit travel on the tributary highways.

The construction of the bridge across Eggemoggin Reach has brought to fulfillment a project that had been urged intermittently for a good many years. It has involved the exercise of much engineering skill and the display of a great deal of resourcefulness on the part of those directly responsible for the work of erection. Nature did not make the undertaking an easy one; and difficulties of considerable magnitude had to be mastered to make accomplishment possible within the time limit set by the authorities.

The Sargentville-Little Deer Isle site was chosen because at that point a structure 2,509 feet long would suffice to span the reach. A suspension type of bridge was decided upon: and an appropriation by the State Legislature, a PWA grant, and the sale of revenue bonds by the Deer Isle-Sedgwick Bridge District conjointly provided the sum of $970,000. Knowledge of



LOCATION MAP

The Deer Isle-Sedgwick Bridge crosses Eggemoggin Reach between Sargentville on the mainland and the Village of Little Deer Isle on the island of that name. A causeway connects Little Deer Isle and Deer Isle.

what has been achieved will disclose how well that money has been spent. The consulting engineers developed a number of schemes and changed the locations and dimensions of some of the principal features of the generally approved plans before they found the one that would cost least and best meet the circumstances imposed by nature.

Eggemoggin Reach is really an arm of the Atlantic, and at times and seasons is exposed to the full force of the storms that sweep the coast of Maine. In winter, much floating ice is carried to and fro by strong currents alternately bound in from the ocean and out from expansive Penobscot Bay. Normally, the tidal range is 10.2 feet, and would inevitably call for special provisions in sinking and completing large piers offshore. The necessary bedrock slopes in a pronounced degree from both banks toward the deepest water in mid-channel; and that rock is covered with an overburden, from 2 to 16 feet deep, composed of an upper course of relatively soft mud and a lower one of hardpan. That overburden is not thick enough to help hold a cofferdam in place against strong tidal currents or the buffeting of storm waves. Even so, the main piers for the two suspension towers had to be tied to bedrock: and according to the original plans they were to be built within cofferdams constructed of steel sheet piling driven down to rock. So much for the conditions that had to be squarely met or sidestepped in some no less satisfactory manner.

The Deer Isle-Sedgwick Bridge consists of three spans having a combined length of 2,048 feet. The central span is 1,080 feet long, and the side spans are each 484 feet long and linked to the neighboring shore by a massive reinforced-concrete anchorage for the suspension cables and a steel viaduct connecting with an embankment that ties in with a highway. The north approach is 167.5 feet long: the one at the Little Deer Isle end, including two sections of steel viaduct and an intermediate anchorage, has a length of 293.5 feet.

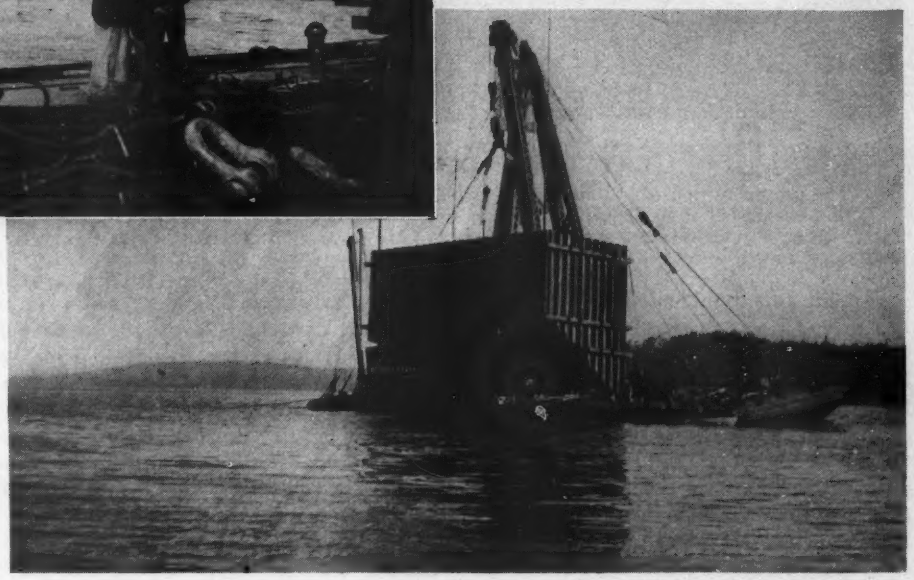
Because Eggemoggin Reach is a much navigated waterway, the War Department required that the main span should afford a clearance at mean high water of not less than 85 feet at midlength for a distance of 200 feet. This has been met by giving the span a slight vertical curve at that point for 400 feet and making the approaches slope 6.5 per cent. While this gradient is a pronounced one, compared with other bridges, it has enabled the designers to adopt viaducts of short length and to save expense in their construction.

The two main towers rise to a height of 213.25 feet above mean sea level, and over them are strung, 23.5 feet apart, the two main cables that have an external diameter of 7.5 inches and are made up of nineteen galvanized-steel strands 1.5 inches in diameter. The suspenders that connect the cables with the span are 28 feet apart. Each has a diameter of 1⅛ inches, is composed of seven strands, and is galvanized. The two parts of each suspender are looped over a collar on the main cable, with the two lower ends secured to opposite sides of the top flange of the proper 6.5-foot stiffening girder of the span. The suspenders, as well as the cable strands, were prestressed at the plant of the manufacturer—measured to accurate, predetermined length when under a prescribed ultimate load stress so that no adjustments as to length would be needed in the field. That provision not only prevented loss of time but also a great deal of worry during construction operations.

The floor system of the bridge is made up of transverse beams 24 inches deep and of 74-pound section. They are spaced 7 feet apart, and upon them rests a 20-foot concrete roadway, 4.5 inches thick, in which is embedded Reliance steel truss-armor for reinforcement. Along each flank is an emergency sidewalk 15 inches wide. The roadway is designed for two lanes of traffic and for carrying automobiles and motor trucks, in the latter particular giving Deer Isle a service that will be of great value to her industrial activities.

To appreciate the steps by which the crossing was built it would be well to start from the foundation and to follow the various stages upward. The contract for the substructures was signed on December 3, 1937. It stipulated that one tower pier should be finished by June 1, 1938, and that the other should be ready for steel erection on or by August 1—any delay inviting substantial penalties. The coast of Maine is subject to rigorous winters—low temperatures, floes of ice, and severe storms. Any open cofferdam constructed during that season and the early spring would entail hazardous work and possibly demolition before it could be unwatered and used to place in the dry the more than 1,700 cubic yards of concrete required for each base section of the piers. The contractor got the better of nature by making preparations within the shelter of New York Harbor, hundreds of miles southward, where he fabricated the materials for two complete cofferdams—one for each pier—that could be assembled in a convenient cove adjacent to the bridge site and lowered at the proper time on to their rocky resting places deep underwater.

When all this steelwork was ready, together with certain metal forms and necessary equipment for submarine work, it was loaded on a sea-going floating derrick, capable of lifting a unit mass of 250 tons, and transported to the point of use where it was moored in a protected cove early in the spring of 1938. First one and then the



LOWERING COFFERDAMS

The structures were fabricated on land, towed to the sites of the piers for the bridge towers, and sunk in position. Notice how the bottom edge was cut away to fit the slope and irregularities of the water bed. The picture below shows one of the 135-ton cofferdams about to be lowered by a floating derrick.

Courtesy, Merritt-Chapman & Scott Corp.

other cofferdam was erected on blocks upon the deck of a barge. Their walls were formed of arch-web steel sheet piling of 27-pound section, and were braced internally on all four sides and at two levels, 16 feet apart, by rectangular framing of wide trusses. On the outside, at the same levels, they were stiffened by wales of 10-inch-wide flange beams bolted through the sheet piling to the interior reinforcing framework. One side of each cofferdam was much higher than the others, and this was similarly braced inside and out at a still lower level, the bracing extending partway along the two adjoining walls. The four bottom edges were given a slant that approximated the known general slope of the bedrock on which the coffer was to rest.

About the time this work was in progress, the two pier sites were cleared of their overburden by open dredging, divers finishing the job with powerful water jets. The rock was rough and more or less worn away in irregular steps—the slope towards the middle of the channel varying at the two locations but having a general inclination of 1 on 2.6 at the north-pier site and of 1 on 1.9 at the south-pier site. The average depth at the former is 72 feet and at the latter 54 feet below mean sea level. After the rock was cleared, divers with S-68 Jackhamers drilled a hole at each corner of the area to be occupied by a pier base, drove a dowel into each, and then strung a wire around the four dowels to mark the outline of the base. The rock was found to be extremely hard.

The next step was to determine accurately the contours and profiles of the rock throughout the area of the cofferdam and the concrete base block to be poured within that form. These particulars were obtained with the aid of a sounding rod consisting of a lattice derrick boom of steel 80 feet long and weighing 8 tons. At its lower end, the boom was fitted with a steel point of large diameter, and at an elevation well above water was attached a crosspiece or level rod to facilitate the taking of readings by means of instrument stations established on shore. Errors that might have been introduced by rough water or changing stages of the tide were obviated in this manner.

Soundings were taken at intervals of 1 foot all around the perimeter of each caisson area and on 5-foot squares within the enclosure. In the latter case, wherever the rock slope was found to exceed 1 on 1.75, a 2-foot hole was drilled for every 8 square feet of such surface. In that hole was inserted for half its length a steel dowel 4 feet long and 2 inches in diameter, after which neat cement was introduced to bind the dowel to the rock. This was done to make the anchorage of the pier base to the rock still more certain, even though the rough surface of the latter generally afforded unusually good keyways. Thirty dowels were thus placed at the north-pier site and 75 at the south-pier site. Air for the subaqueous operations of the Jackhamers was furnished by a 2-stage, 315-cfm. Ingersoll-Rand compressor.

With a site made ready, and the bottom edge of its cofferdam cut to fit the rock, then the barge with the coffer was towed out and moored directly over the site—a range pole at each corner making it possible, by triangulation from shore stations, to do this with precision. Next the floating derrick, securely anchored alongside the barge, lifted the 135-ton cofferdam clear so that the barge could be moved away from under. Then the derrick began slowly to lower the structure, which was provided with adjustable steel spuds, one at each corner. Those spuds touched the rock bottom first, and thereafter functioned as guides and steadied the cofferdam as it settled to the water bed. One was thus placed without a hitch, but the other cofferdam had to be lifted to burn away a small section of bottom edge so that it would fit over a projecting rock that the sounding rod had missed.

Each cofferdam has an average height of 29 feet, and in plan its inside measurements are 28x60.5 feet. After planting, divers placed a row of bags filled with dry-batched concrete outside along the toe, and with that done, the interior of the structure was filled with tremie-poured concrete, the steel of the walls and the interior bracing becoming integral parts of the base block of the pier. The top of the north-pier base block is 43 feet below mean sea level: that of the south-pier block is 25 feet below. Each is surmounted by a distribution slab, 10 feet high, that has rectangular outer sections tied together by a massive crosstie.

ERECTING FLOOR STRUCTURE

The central section of the main span and the shoreward ends of the side spans were first suspended from the cables, thereby distributing the weight gradually and preventing any undue stressing of the towers and the masonry connections.

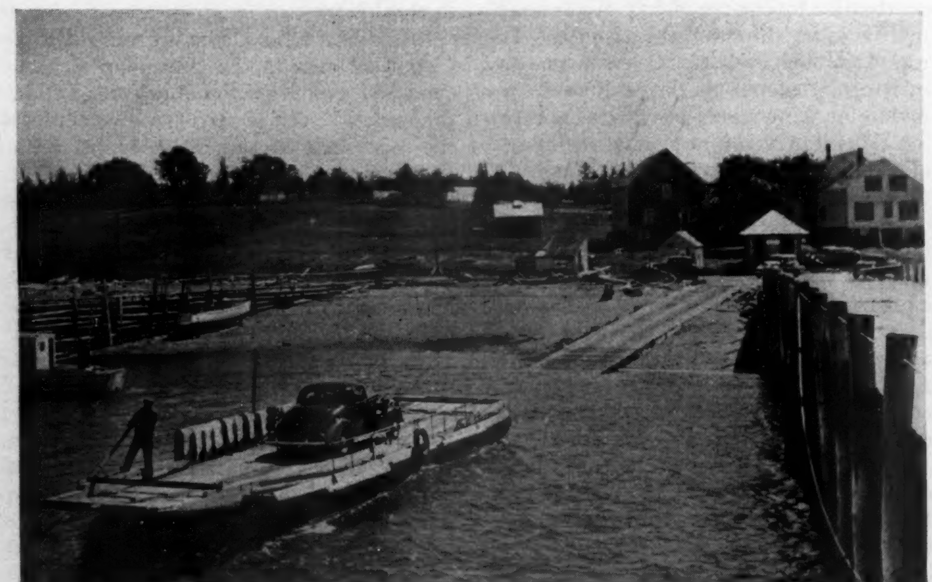
In plan, this dumbbell-shaped structure has over-all dimensions of 24x56 feet. Each rectangular section measures 17x24 feet, and the crosstie is 12 feet wide and 22 feet long. The steel forms for these slabs are heavily braced internally by horizontal trusses at several elevations and serve as permanent reinforcing. The concrete was poured by the tremie method. But before that work was started, a steel cylinder was secured to the interior framing of each rectangular end section of the slab form. This cylinder was 5 feet high and 14 feet in diameter and carried a flange drilled with bolt holes. When in position, it projected 3 feet above the top of the form. By this arrangement it was possible for divers to attach additional cylindrical sections, reaching above water, which, when pumped out, permitted concrete for the two columns of each pier to be placed in the dry. These columns rise to an elevation of 25 feet above mean sea level and are tied together above water by a massive reinforced-concrete strut. In the solid top of each, embedded to a depth of 17.5 feet, are ten 3-inch anchor bolts which pass through and are attached to the base structure of one of the two legs of the superposed main tower.

Emphasis has been laid upon the really difficult work of constructing the piers for the towers. These required the use of floating equipment, while most of the viaduct piers and both anchorages are located on sites that are exposed at low tide and that enabled the subcontractor, Ellis Snodgrass, of Portland, Me., to carry on his job for the most part between tides and with land equipment. Some of the more shallow foundations were built inside of low sandbag dams. The abutment, anchorage, and Viaduct Pier 1 at Little Deer Isle were inclosed within a single double-walled timber cofferdam with a puddled core. At outlying Pier 2 the overburden of stiff blue clay was so firm that it could be excavated down to rock, at Elevation −19, without recourse to a coffer. With each high tide the pit was flooded; but the walls stood practically vertical. As the water receded, the excavation was pumped dry and operations were resumed until the prescribed depth was reached and the forms were placed in which the concrete was poured between tides.

The contractor for the superstructure erected the two main towers, the main cables, and the suspended span with the aid of a floating plant. A derrick boat was used to build the main towers up to a height of 78 feet above the top of the piers, and from that elevation to the top the work was completed by means of a creeper traveler. The sections handled by the latter were assembled near the foot of each tower on a timber frame cantilevered from the tower and within reach of the floating derrick that assisted in the operations.

After the cables were strung and their strands secured to the anchorages by the Robinson system of adjustable strand sockets, the suspended span was constructed in sections, beginning at midlength of the main span and then extending the side spans outward from the shores so as to increase the load on the cables gradually and to distribute the weight in a manner that would cause no undue stressing of the towers and the masonry connections. Thanks to careful planning, all operations were carried forward rapidly, and the Deer Isle-Sedgwick Bridge reflects much credit on everyone concerned.

The joint board in charge of the building of the bridge was composed of the late Raymond C. Small, secretary of the Deer Isle-Sedgwick Bridge District Trustees, and L.D. Barrows, state highway engineer, as secretary of the joint board. The highway commissioners of Hancock County were also represented; and these several interests will have to do with the operating and maintaining of the toll crossing. The structure was designed by Robinson & Steinman, consulting engineers, New York City, with R. M. Boynton in charge of design and D. G. Letourneau resident engineer. The PWA was represented by Frank Slane, senior engineer of the New England District. Merritt-Chapman & Scott Corporation was the general contractor for the substructures, with Frank W. Barnes construction manager; and the Phoenix Bridge Company, of Phoenixville, Pa., was the general contractor for the superstructure—J. R. Lambert being chief engineer and J. F. Kinter superintendent of erection.



THE FERRY THAT RUNS NO MORE

Prior to the construction of the bridge, passengers and motor cars made the trip to Little Deer Isle by ferry scow. The towboat is visible at the left.

Scientists Work with Gas Pressures of 53,000 Pounds

THE hurricane that tore through New England last fall was, say weather experts, the result of an area of very low barometric pressure moving up the coast from the South. Winds of devastating velocity swept away everything in their path, and air velocities of well over 100 miles an hour were registered. Nature causes such winds by a decrease in air pressure; but scientists have produced even higher winds by increasing the pressure.

Working with gases at pressures of several tons per square inch and at temperatures of more than 12,000°F.—much hotter than the surface of the sun—scientists in the General Electric research laboratory at Schenectady, N. Y., have created winds with velocities of almost unbelievable values and have unearthed some hitherto unknown facts regarding the properties of electric arcs. They have found, for instance, that in hydrogen at high pressure it is not possible to maintain an electric arc even briefly, the velocity of the gas being so high that the arc is immediately extinguished.

Behind a barricade of sand bags and within a thick-walled cylinder of exceptionally strong steel, different gases are compressed to pressures as high as 3,600 atmospheres, or a matter of about 27 tons per square inch. A switch is closed, and a heavy current arcs across the chamber. A thick window of clear fused quartz in the chamber permits the arc to be seen at such a relatively low pressure as 200 atmospheres; but it is upon oscillographs and other electric measuring devices that the scientists depend for records of what takes place inside the pressure chamber at higher pressures.

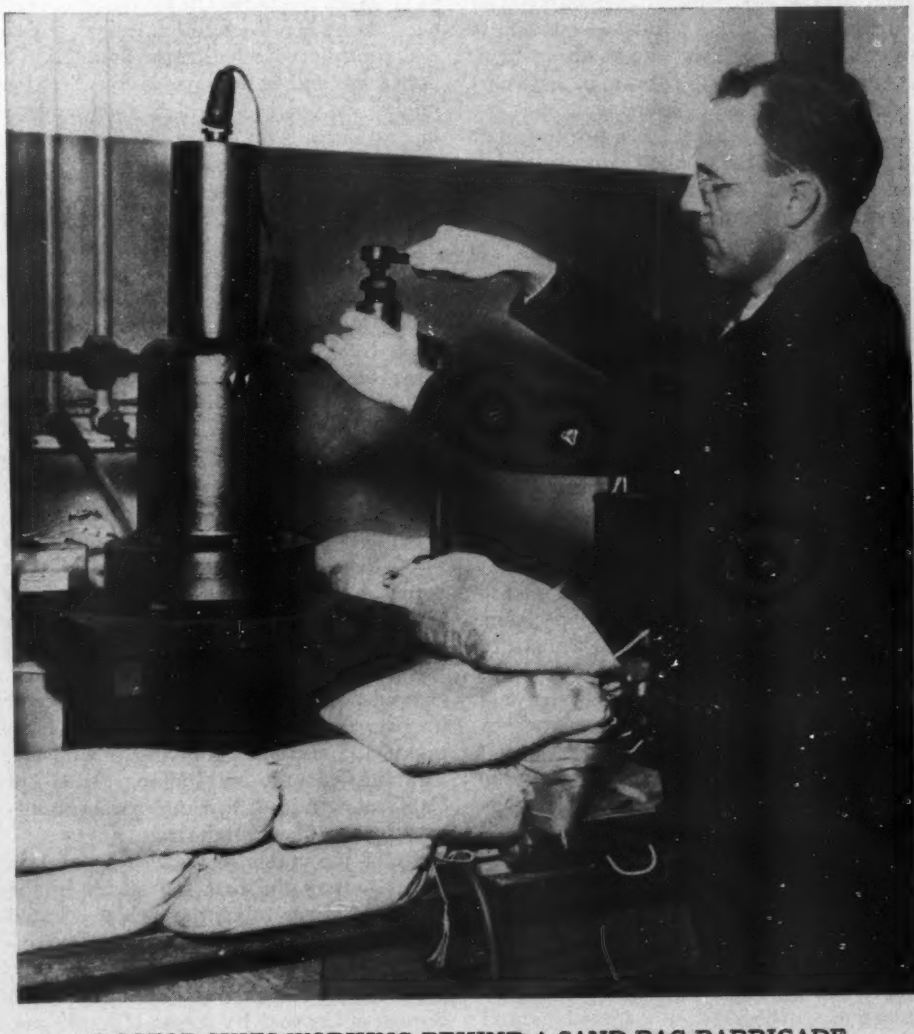
Dr. C. G. Suits, who has been in charge of these researches, has had arcs burning in gases under pressures as high as 3,600 atmospheres; but accurate measurements at such enormous pressures have been impossible because of the limitations of present equipment. However, he has been able to make accurate measurements at pressures up to 1,275 atmospheres, or 9 tons per square inch—that is, at pressures ten or more times higher than those previously reported for such investigations.

The general results of his experiments have been to show that the electrical properties of the electric arc undergo profound changes in consequence of pressure. For example, an arc carrying 10 amperes, which would have a diameter of about ½ inch in air, contracts to a tiny thread at the highest pressures. Similarly, the voltage drop necessary to drive the current through the arc column increases five to eight times at pressures of 1,000 atmospheres.

One of the most unusual results of the investigations is the behavior of the hydrogen arc at high pressure. Compared to the arc in nitrogen, the hydrogen arc has an extremely small cross section even at atmospheric pressure, being similar in this respect to the nitrogen arc at pressures exceeding 100 atmospheres. It is found that the effect of pressure in the hydrogen arc is such as to destroy its stability completely, so that it cannot be operated at all in the range above 20 atmospheres. Arcs in helium have been operated at pressures above 200 atmospheres without the development of any abnormal instability. As a result of more recent study, these effects are all attributed to convection currents or "cyclones" in the gas.

In the arc column it is known from measurements by sound waves that the temperature of a gas reaches unbelievably high values. These lie in a range between 11,000 and 12,500°F. When the arc gas is heated it expands and becomes very buoyant, and this buoyancy force causes convection currents around the arc. Doctor Suits has measured the velocity at which these convection currents rise in an arc in air, and has found it to be somewhat more than 4 feet per second in the center of the arc column. As the pressure goes up, so does the velocity, leading to the belief that there are convection currents of very high velocity at high pressure. Although the convection velocities at high pressure have not been measured directly, there is abundant evidence of their existence.

If one should make a simple calculation for the 1,000-atmosphere range from the known convection velocity of 4 feet per second at one atmosphere, that calculation would show that the convection velocities become higher than the velocity of sound. By reason of a well-established law of the physics of gases, this is impossible. To explain why the convection velocities do not actually increase as rapidly as pressure, it should be said that there is a most important counteracting force in the observed decrease in size of the arc column, which means that the volume of gas available for bringing about the buoyancy force is somewhat reduced. Although these convection velocities cannot exceed sound velocities, they do attain very high magnitudes at high pressures. High pressures in a completely closed chamber thus permit an electrical engineer to obtain a gas blast without the use of complicated pumps and auxiliary equipment.



DOCTOR SUITS WORKING BEHIND A SAND-BAG BARRICADE

BIG OR SMALL BUSINESS?

THERE is a popular impression in this country that a "big" business is always a very profitable one. For some reason, largeness seems to connote opulence in a surprisingly great number of minds. There are, of course, many big organizations that make money fairly regularly; but there are more that do not. Numerous cases could be cited in either class. Strangely enough, it is not unusual to find a great disparity in earning power among a group of large corporations in the same industry.

The truth is that there is an optimum size of manufacturing plant or organization for most lines of endeavor. Many concerns have run into financial troubles by expanding too rapidly: others have fallen by the wayside because they chose not to grow. Determination of the most advantageous size offers an interesting field of study. There are no hard and fast rules to follow, and it is impossible to generalize. Even the word "big" is no criterion, for a big business or a big plant in one field would be a small one in another field. For any industry, however, there is a size of organization that is most likely to succeed, and it can be ascertained by examining the mortality rates in that particular industry over a number of years including periods of both general prosperity and general depression.

Two members on the U. S. Bureau of Mines staff recently completed a study of the lime industry in which they analyzed reports submitted to the Bureau over a 29-year period. They found that small plants, producing annually less than 1,000 tons each, account for an insignificant percentage of the total production of lime, and that this percentage is decreasing year by year. Medium-sized companies with an annual output ranging from 10,000 to 50,000 tons each are most regular in their operations. Big companies, each producing more than 50,000 tons a year, are extremely sensitive to booms and depressions and display wide fluctuations in their operating rates. The conclusion drawn is that there is a size of plant that is most efficient and that growth beyond that point does not pay.

PRINCIPAL MINING STATES

CONTRARY to popular opinion, most of the ten leading mining states in the United States are east of the Rocky Mountains. This is true regardless of whether the production of petroleum and natural gas is considered as mining, a point on which even governmental bureaus do not agree. The law defines a mine as any working for the extraction of minerals. The Bureau of Mines interprets this broadly, and classifies under mining the production of oil, gas, brine, sulphur, and even mineral water. The Bureau of Census, on the other hand, excludes it. Accordingly, the statistics compiled by the two bureaus differ widely. There are also different measures of the volume of the mining industry. One is the value of the products: another is the number of persons that are engaged in mining activities and the amount of wages they receive.

On the latter basis, the Bureau of Census puts Pennsylvania first among all the states. In 1935, nearly 1,800,000 of its population were classed as mine workers, and they constituted nearly one-third of the persons so employed in the country. Other leading states, in the order of their importance were: West Virginia, Kentucky, Illinois, Ohio, Alabama, California, Virginia, Colorado, and Indiana. All except California attained their rank primarily because of their coal production.

Six of the states just mentioned retain places among the first ten states in the Bureau of Mines' tabulation, which is based on the value of the products and which includes petroleum, natural gas, sulphur, pyrites, and other products excluded by the Bureau of Census. By reason of its oil, gas, and sulphur fields, Texas leads this list with a total production valued at $528,000,000; but Pennsylvania is a close second with $520,000,000. The next eight states, in proper order, are: California, Oklahoma, West Virginia, Ohio, Louisiana, Kentucky, Kansas, and Illinois. It is of interest to note that metallic minerals play an insignificant part in giving any of these states their rating. Gold stands third in value among the mineral products of California, while zinc is fourth in Oklahoma and in Kansas, and iron, copper, lead, and silver are not of importance in any of the ten states.

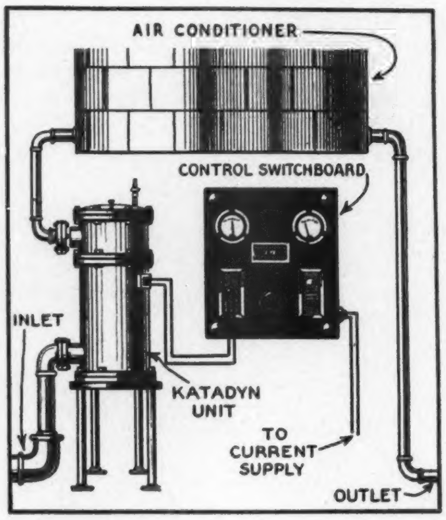
DRAKE'S FOLLY

JUST a few days ago the petroleum industry observed its eightieth birthday. In 1859, Col. E. L. Drake, a retired railroad conductor, began drilling a well near Titusville, Pa. Skeptics dubbed it "Drake's Folly," but the tools had penetrated only 69½ feet when petroleum was struck on August 27.

The petroleum industry of the country now employs more than 1,000,000 persons. pays wages of $1,500,000,000 and taxes of $1,125,000,000 annually, and sells its products for more than $4,000,000,000. There are 360,000 producing wells in 22 states, some of them as deep as 13,000 feet. In Drake's time, petroleum was wanted chiefly for its supposed medicinal properties and to produce illuminating oil. Now we obtain countless useful derivatives from it; and scientists say that some day it will provide us with building materials, fabrics, and even food.

More than 21,000,000,000 barrels of petroleum have been extracted from the ground in the United States so far, and it is estimated that the known recoverable reserves aggregate 17,000,000,000 barrels. Geophysical prospecting and improvements in equipment for deep drilling have removed all fears of a shortage for many years to come.

Silver as a Sterilizer for Air-Conditioning Systems



AIR-conditioning systems using water sterilized with silver ions do not, it is said, necessitate frequent shutdowns for cleaning. This is of considerable advantage in hospitals, for example, where 24-hour service is required. Silver, it has been discovered, has great bactericidal powers, and minute quantities of this metal in water will prevent the growth of algae and fungi and will kill pathogenic bacteria. By means of suitable equipment it is employed today to purify water for drinking, for rinsing in dairies, breweries, etc., and for swimming pools, as well as to sterilize vinegar, cider, fruit juices, and other bottled products, together with the pipe lines and filters through which they are passed and the bottles in which they are put up for marketing.

One of the newest applications of silver in this field is in air-conditioning, where it serves to control the growth of microörganisms and the accumulation of slime in the water that is used to wash and to cool the air. The apparatus by which this is accomplished has been developed by the Katadyn Process Corporation, and is interposed in the water line just before it enters the air washer. It consists of an activator—a cylindrical housing in which are mounted pure metallic-silver electrodes arranged in pairs to form anodes and cathodes—and of an electric control panel for regulating and measuring the current (about 1.5 volts) which is applied to the electrodes. Current can be supplied by a storage battery or taken from a regular electric circuit. In the latter case a small transformer is included, and if alternating current is used, a rectifier as well. As the amperage and voltage required are extremely low, the annual electric-power bill is negligible.

The quantity of silver passing from the electrodes into the water being treated is proportional to the current flow, and is controlled without difficulty by means of a simple resistance. This has to be checked occasionally, but other than that the equipment needs no adjustments. The amount required to kill algae and harmful bacteria is extremely small, 0.05 part silver per 1,000,000 parts of water being ample. This varies, of course, with different liquids and the degree of sterilization desired. In swimming pools, for instance, it averages 0.15 part per 1,000,000, or approximately an ounce for a 60,000-gallon pool and a daily addition of about 1/10 ounce to make up for loss.

As an example of what can be accomplished by sterilizing the wash water with silver ions, let us cite the case of a regulation spray-chamber type of air conditioner set up in a chemical plant. It has a capacity of 15,000 cfm. The air at the intake and the discharge has a temperature of 95° and 60°F., respectively. Twenty-five gallons of water a minute, at a temperature of 55°F., is required to cool the air. It is not recirculated, as it is used elsewhere in the plant. Even so, spray nozzles and eliminators became plugged with growths, and fungus in colorless treelike masses 3 inches high formed on the floors of the spray chamber, necessitating cleaning once a week in summer and every one or two in winter. With the activator, cleaning is now done once every twelve or sixteen weeks, and, according to the plant management, "The length of time the operating rooms are without conditioning is reduced by 80 per cent."

Thinner Insulation Means More Wires in Cable

AS THE result of a new method of insulation, engineers of the Bell Telephone and Western Electric companies have developed a telephone cable which is of the same size as that now in common use but has a far greater capacity. Both have a diameter of 2⅝ inches; but where the latter contains a maximum of 3,636 separately insulated copper wires, the former is made up of 4,242 wires of the same kind and gauge.

According to a recent announcement: "The feat of placing 606 more wires within the same girth was made possible by an improved technique of wire insulation invented by the Western Electric Company, a method which reduces the thickness of the insulation surrounding each strand." The covered wire produced by it has a diameter of 31/1,000th of an inch, as compared with 34/1,000th. Although the decrease is only 3/1,000th inch, this saving affords enough room for the extra strands.

"The method of insulating the wires," to quote, "is in itself a revolutionary development of the last decade. Prior to the invention of this process, wires intended for cable were insulated by wrapping paper ribbon spirally around them. Then it was discovered that paper pulp could be formed around the wire; and now giant machines literally manufacture a thin coating paper right on the wires, 60 strands at once, as they pass through a bath of pulp." The first installation of the new cable was made in the Jersey City area by the New Jersey Bell Telephone Company. The line has a length of 14,000 feet and was manufactured at the Kearny, N. J., works of the Western Electric Company.

Diving Equipment for Prospectors

WHAT the up-to-date prospector wears might well be the title of the accompanying picture. It is the newest thing in apparel for the man with the geologist's hammer, and was designed to enable him to follow an outcrop that disappears beneath the waters of a lake or stream. When not in use, it is strapped to the back like a pack. The diving equipment weighs approximately 30 pounds, and is heavy enough to carry the wearer underwater but not too burdensome to prevent him from moving with ease with a swimming motion. It consists of a mask, an oxygen flask, and a lung that automatically feeds the air to the diver through flexible hose leading to the mouthpiece. The self-contained apparatus is said to be sufficient for one hour's stay at its maximum depth of 40 feet, or for two hours in shallower waters. The practice is for two men to work together, the diving prospector carrying down with him, in addition to his waterproof flashlight and hammer, a signaling line by means of which he can communicate with his companion at the surface. The picture is reproduced through the courtesy of *Mining and Metallurgy*.

Industrial Notes

After three years of research and experimenting, the Hewitt Rubber Corporation is now manufacturing transmission belts that are primarily designed for use in shops and plants where contact with oil is unavoidable. The new belting is of cotton duck, the several plies of which are bonded together by a special process with friction and skim compounds of Neoprene—a synthetic Du Pont product that is proof against oil. These coatings on the surface and between the plies protect the cotton fabric against wear, ply separation, and softening from oil at high temperatures, and give the belting exceptional flexing life with high-speed pulleys. In addition, the company claims that factory and field tests have proved that Duroil Hewprene transmission belts require a minimum of take-up and maintenance supervision because of low stretch, which is attributed to the fact that they are oilproof, and that they hold wire fasteners well under severe working conditions.

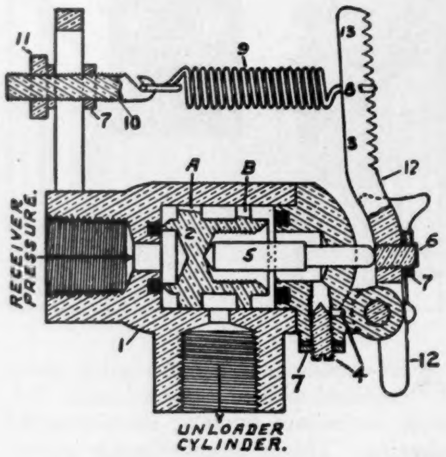
The latest addition to the Hanna line of pneumatic riveters features speed of operation—a complete stroke, forward and back, in less than one second, it is claimed. When operated with air at 80 pounds pressure per square inch, the unit exerts 20 tons on the dies, which will drive rivets up to ⅜ inch in diameter cold and ½-inch rivets

hot. The die stroke may be any length up to 3 inches, and the machine will exert its rated pressure uniformly upon the work even though there may be a variation of as much as ⅜ inch in rivet length and thickness of grip. The driving jaws are of the Alligator or Nut Cracker type shaped to avoid interference with the assemblies being riveted. They are made of standard, heat-treated alloy-steel bar stock, are simple in design, and can be removed quickly, permitting the use of any number of stakes to meet requirements. The power of the air cylinder is multiplied and transmitted to the driving jaws through a hardened and ground alloy-steel wedge and antifriction roller bearings, making for low air consumption. As the accompanying illustration shows, the mechanism is provided with a foot-controlled valve that can be moved about for most convenient operation.

As a safety measure for driving at night or during a fog, some 15 miles of roadsides in Essex and Leicestershire, England, have been provided with curbing that is part glass and that serves as a substitute for white paint markings. The curb proper is of concrete and is designed to receive panels of white Vitrolite, a durable opaque glass that has excellent reflective properties and is said to be much easier to see in the dark than white paint. While the first cost is probably higher, safety alone would seem to justify the added expenditure. That is offset, however, by a reduction in maintenance cost, as the need of frequent repainting is thus eliminated.

So truck and bus operators may know when pneumatic tires have reached a stage where they need attention, the Denham Tire & Rubber Company is producing theirs with what it calls a Recap Indicator. This is a line of red spots, disposed circumferentially, that begins to appear as soon as a tire is worn down to a point where retreading is profitable. If that is done promptly, says the manufacturer, it is good for 56,000 miles under ordinary conditions —25,000 miles before recapping and 31,000 miles after recapping, the additional 6,000 miles accounting for the service the tire will give between the time the red spots become visible and nothing is left of them.

Controlled and positive operation is claimed by R. Conrader Company for its R-C Pilot Valve for air compressors and pumps equipped with unloaders. It is available in the plain or the strainer type, and with any one of six sizes of cadmium-plated air-control springs designed for pressures up to 600 pounds per square inch. Each spring is specially tensioned and has a lubricated dampener that prevents it from vibrating or recoiling when the pilot valve loads or unloads a compressor. This permits the valve to be set for a slight variation between load and no load. Because of their location outside the valve proper and air cooling, the springs are said to retain their temper for life. According to the manufacturer, predetermined maximum receiver pressure is instantly delivered by the pilot to the unloading device to unload the compressor; and at predetermined minimum receiver pressure the pilot instantaneously shuts off the receiver pressure and exhausts all pressure in the un-



DETAILS OF PLAIN TYPE

1, Body; 2, piston; 4, vent-adjusting screw; 5, stem; 6, adjusting screw; 7, lock nut and washer; 9, spring; 10, spring hook; 11, adjusting nut; 12, lever with hand unloader; 3, 8, 13, indicate respective notches on lever. (If compressor is to be unloaded at 100 pounds maximum pressure and loaded up at 92 pounds minimum pressure, using Spring No. 4, the latter is tensioned for 100 pounds maximum pressure and hooked in Notch 8 on the lever. If similarly tensioned and hooked in Notch 5, the compressor will unload at 100 pounds and load up at 83 pounds, etc.) A and B, tapered slots for release of air to unloader cylinder.

loader to load the compressor. The cycle of operations is repeated as receiver pressure rises and falls. The valve is entirely open or closed at all times, thus eliminating chattering. There is no loss of air in either position of pilot, and therefore no lessening of compressor efficiency.

French engineers recently resorted to an unusual method in testing the carrying capacity of a suspension bridge. The structure is 554.7 feet long, and consists of a 442.7-foot main span and of two side spans, each 56 feet long. Instead of weighting it down with heavily loaded trucks and pig iron, they decided to use water, which could be obtained and disposed of easily. The water was pumped from the river into eight wooden tanks into which the deck was divided. The tank walls were 2 feet high and made waterproof by covering them with tarpaulin cemented to the floor and sides of the bridge with plaster. When it had served its purpose, the water was drained through plugged holes in the floor. In this way the structure was subjected to the desired load test at much less cost than the work could otherwise have been done.